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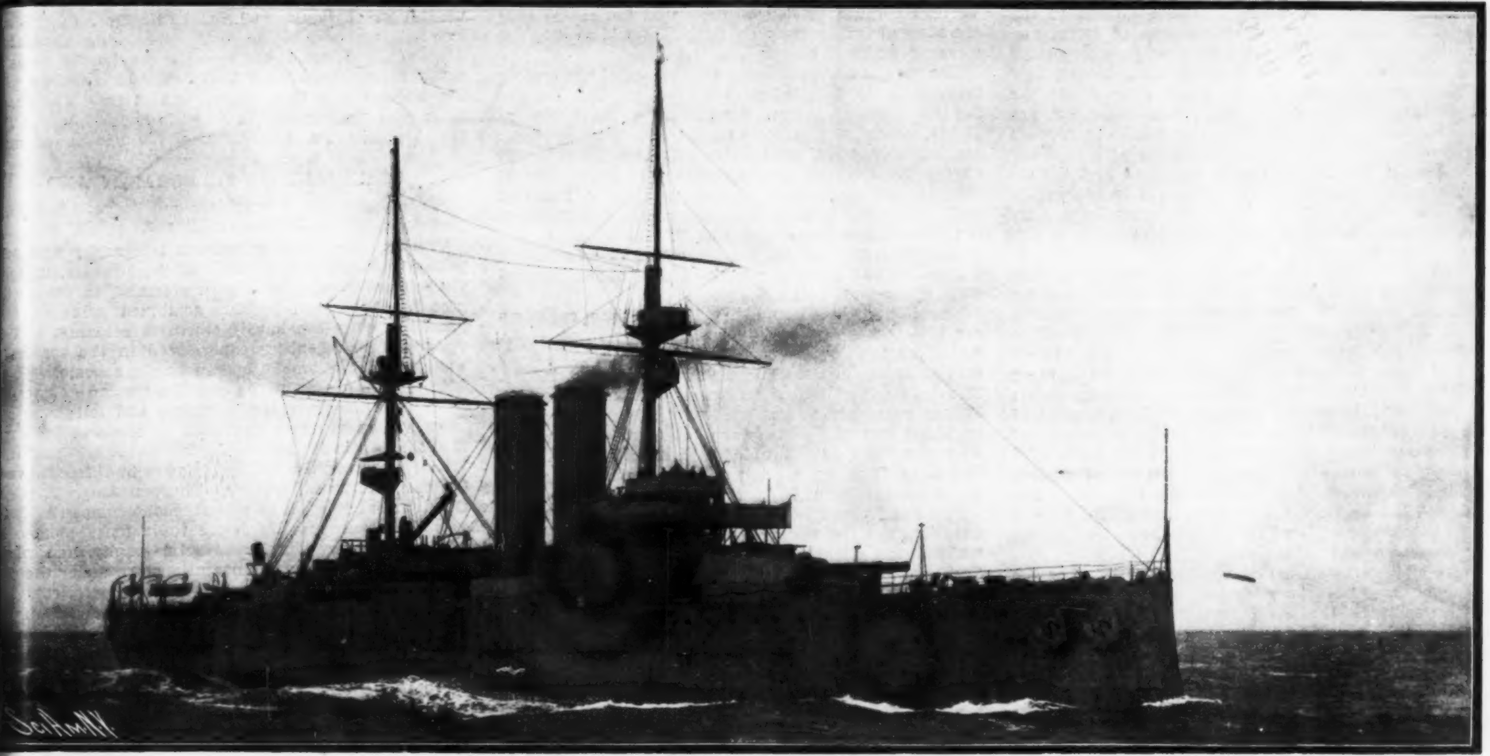
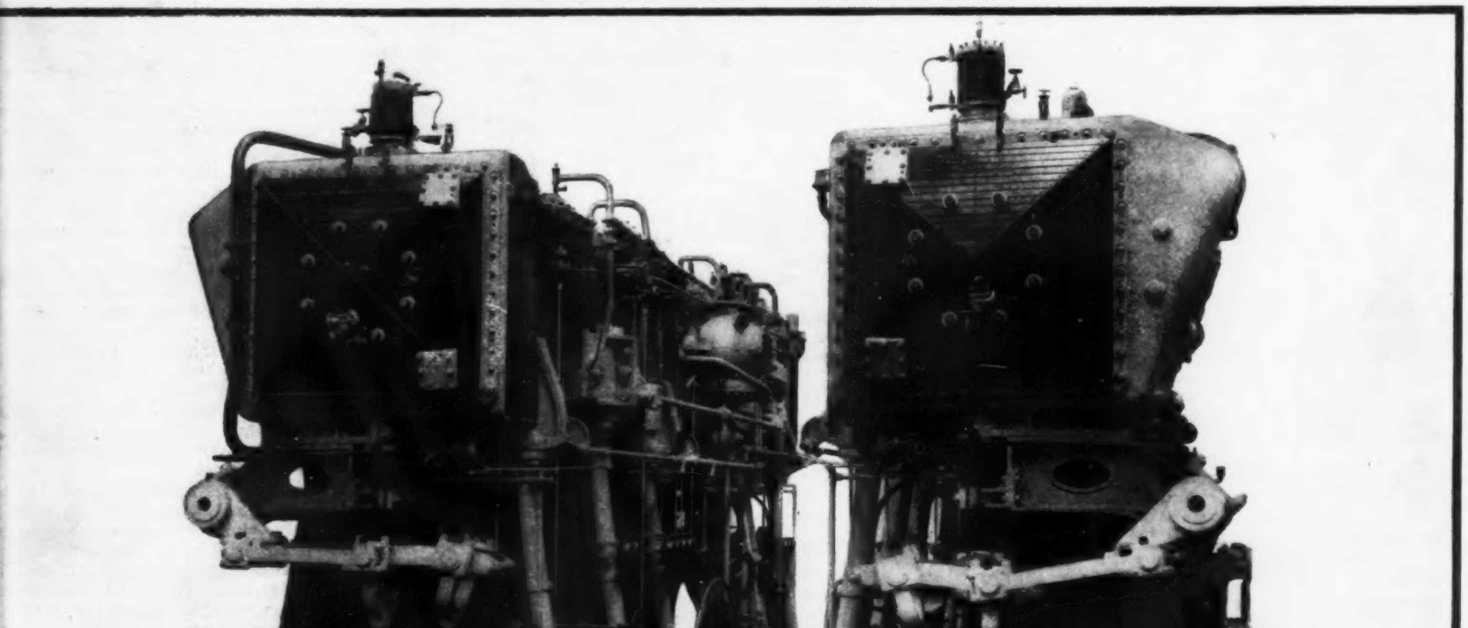


THE NEW BATTLESHIP "DOMINION" OF THE BRITISH NAVY.



THE 18,400 INDICATED HORSE-POWER ENGINES OF THE "DOMINION."

THE NEW WARSHIPS FOR THE BRITISH NAVY.

THE NEW WARSHIPS FOR THE BRITISH NAVY.

By the English Correspondent of the SCIENTIFIC AMERICAN.

THE British navy has now received the first two battleships of the "King Edward VII." class, which now rank as the largest and most powerful vessels possessed by this power. The first of these two warships, from which the class takes its name, the "King Edward VII.," was built in the Admiralty dockyard at Devonport, while the sister ship "Dominion" was constructed by Messrs. Vickers, Sons & Maxim, Ltd., at their naval construction works at Barrow-in-Furness, and has been handed over complete with her armament ready for commission in the navy.

These two vessels measure 425 feet between perpendiculars, with a beam of 77 feet 9 inches, a molded depth of 43 feet, and a displacement of 16,400 tons. The design of these vessels is somewhat different and more symmetrical than the recent additions to the fleet. The sheer runs clear from stem to stern, and is unbroken by either anchor beds or superstructures of a cumbrous appearance, the line being broken only by the turrets containing the heavy guns, while the self-canting anchors, except their heads and flukes, are withdrawn into the stem of the vessel. The funnels too are of neat design and harmoniously placed. They are of equal dimensions, and although at first the arrangement adopted presented difficulties in connection with the several uptakes, these problems have been successfully surmounted, and the general beauty of the design preserved.

The most important features of this class of warship, however, are in connection with the fighting and defending armaments. For defensive purposes there is a belt extending from the after armored bulkhead to the ram. For the greater part of this length the thickness of the armor is 9 inches, and is reduced in three stages to 2 inches at the forward end. The maximum thickness of this belting is continued from a point of 5 feet below the load line at the citadel to a depth of about 3 feet above it. Then comes a thickness of 8 inches, and finally a belting thickness of 7 inches, which is continued right up to the upper deck. Owing to the success and value of the thin armor carried over the counter of the "Triumph," the same practice has been adopted in this class.

Several deviations from conventional practice, as the result of practical experiments, have been made in connection with the main and secondary batteries. Hitherto the scheme of design has been to place these two batteries of guns at a higher or lower level as compared with the sea level when the ship is loaded at her normal draft.

The primary armament comprises four 12-inch and four 9.2-inch guns. The 12-inch guns are placed in barbettes of 12-inch armor, with hoods provided with sloping sides. The two forward 12-inch guns, in view of the fact that they would undoubtedly require the highest command, when approaching and sighting an enemy at a considerable distance, are consequently placed at the highest altitude, which is about 23 feet 6 inches above the sea level. On the other hand, the stern pair of 12-inch weapons which, under normal conditions, have a stern range and do not require to be fired at such long ranges as those foward, are placed at a somewhat lower level. There is, however, one other important point why this arrangement should be adopted, and that is due to the imperative necessity of these gigantic battleships to keep the center of gravity low down, so that the fair metacentric height of 3 feet 9 inches may be secured, which is practically accomplished in this class. The pairs of 9.2-inch guns placed forward and astern respectively, and to all intents and purposes utilized as a support to the fire of the larger weapons, are placed at the second level. These weapons are mounted separately in turrets of 7-inch armor on the upper deck, one at each quarter. These turrets are made to swing round, so that an extensive arc of training is thereby assured.

The secondary batteries comprise five 6-inch guns mounted on each broadside on the main deck. These guns are placed between 8 feet and 9 feet below the level of the primary armament, and their command is such as to keep them clear of the water when the vessel rolls. Advantage has been taken in the arrangement of these guns on the Japanese warship "Mikasa," in that they are mounted within the 7-inch armor in a concentrated casemate. For defense against torpedo attack fourteen 12-pounders, fourteen 3-pounders, and two Maxims are mounted in convenient positions, while there are also four submerged torpedo tubes.

For the convenience of the gunners serving the 9.2-inch guns the sides of the turrets are upright, only the front portion having an upward slope from the deck. The benefit of this design is that room is afforded for the crew within to work the weapon. The mechanism for loading, traversing, and elevating these guns is of the simplest character. There is a small railroad overhead, which brings the projectiles to a convenient position over the loading tray, which can be swung round to the breach of the gun by a few revolutions of a side handwheel. Within the recesses of the revolving circular turntable beneath the gun the projectile can be held in reserve, and when this supply is exhausted, the ammunition is drawn from the hoist within the turret on the left side of the gun.

Especially noticeable is the improvement carried out in respect to the telescopic sights, so as to overcome the difficulties arising from the shock of recoil, which has always been identified with the bar sight as hitherto adopted. The telescopic sights, by means of which a range of 14,000 yards can be covered, are secured to the immovable trunnions on the gun's recoil jacket. The gun turntable and the accompanying gear rotate upon a huge pintle, which is responsible for the whole security of the turret and gun. This pintle descends into a circular space beneath the upper deck, and is secured rigidly and strongly to the deck below, as it has to withstand the heavy straining forces devolving upon the turntable.

One important feature of existing warships is dispensed with in this new class—the military tops are abandoned. Instead, on the masts are placed large observation stations. These are fitted with range finders, and the guns are trained and directed from these points. The after navigation bridge has also been abolished. Instead there is an admiral's bridge immediately abaft the main navigating station. The towers for the searchlights are still retained, however. Vertical engines in lieu of the usual horizontal type are adopted for the mainmast boat derrick, as they are more efficient and occupy less deck space.

The vessels are provided with engines of the cruiser type, with four cylinders arranged on the Yarrow-Schlick-Tweedy system, developing a maximum of 18,000 horse-power, giving a speed of 18.5 knots per hour. As, however, some remarkable results were achieved during the trials of the "Dominion," a description of this engine equipment, though practically identical with the sister ship, is interesting. In this instance the horse-power developed was 18,348, which is 348 horse-power in excess of the contract requisitions, and a speed of 19.5 knots per hour—1 knot above the contract speed—was attained.

The high-pressure and the intermediate cylinders are 33½ inches and 54½ inches diameter respectively, while the two low-pressure cylinders each have a diameter of 63 inches. The piston stroke is 48 inches. The boiler installation comprises sixteen Babcock & Wilcox water-tube boilers with a total heating capacity of 47,369 feet and a grate area of 1,402.5 square feet. The propellers are four-bladed, measuring 17 feet 6 inches in diameter, a pitch of 18 feet 6 inches, and a developed surface of 86 square feet.

The Admiralty trials of this vessel were of 68 hours' duration, and the whole were carried out in four days without the slightest mishap of any kind. For the first time the Admiralty stipulated that the tests should be carried out under actual war conditions, with closed engine room and other attendant restrictions. The first trial consisted of a 30 hours' cruise at 3,600 horse-power, and an average speed, as recorded by the log, of 12.8 knots was maintained with a coal consumption of 1.93 pounds per indicated horse-power hour, and a water consumption for the main engines of 16.6 pounds per horse-power hour.

On the second trial, which was also for 30 hours at 12,600 horse-power, a speed of 18.3 knots per hour was recorded by the log with a fuel consumption of 1.68 pounds per indicated horse-power and a water consumption for the main engines of 16 pounds per horse-power hour. But the most remarkable result was attained on the measured course at the contract horse-power of 18,000 for eight hours. The mean horse-power developed on this trial was 18,348, and the speed obtained from point to point bearings was 19.5 knots, a highly successful achievement, which places the "Dominion" as the fastest battleship in the fleet.

A few days after the completion of the trials of the "Dominion," the "Black Prince," which belongs to the "Duke of Edinburgh" class, was successfully launched from the shipyard of the Thames Iron Works. Six vessels of this class, which corresponds to the "California" type, are in course of construction, and the "Black Prince" is the second. Although this vessel is of somewhat greater displacement than the "California," being of 13,500 tons as compared with 13,400 tons, it is smaller in size. While the "California" measures 502 feet in length, this latest acquisition to the British fleet is 22 feet less, being only 480 feet long, with a beam of 73 feet 6 inches and a depth of 27 feet 6 inches, as compared with 79 feet and 26 feet 6 inches respectively.

This vessel, together with the "Duke of Edinburgh," are the first two vessels of the British navy designed by Mr. Philip Watts since he succeeded Sir William White as Chief Constructor to the Admiralty, and it belongs to what is described as the first completely belted British ship of present times.

The main defensive armament consists of an armored belt extending the entire length of the vessel and varying in thickness from 6 inches amidships to 3 inches at the stern and 4 inches at the ram to which it is secured. Some 1,600 tons of armor are employed, exclusive of the protected decks. The conning tower is constructed of steel 10 inches in thickness, and a splinter bulkhead 2 inches through separates the 6-inch guns from each other.

The main armament comprises six 9.2-inch guns carried on the upper deck. Two of these weapons are mounted on each broadside, with one forward and one aft respectively, while the other four are each mounted at the quarters. The forward and aft weapons have an arc of fire of 310 degrees, while the broadside weapons have a range each of 180 degrees. The secondary battery consists of ten 6-inch guns mounted in a rectangular citadel protected by 6-inch armor. This vessel is the last to be provided with the 6-inch weapon, as it has now been abolished by the British naval department, but in this particular instance these weapons have been made more powerful than previous guns of their size, being 50 calibers long. Though two of the 6-inch guns can be fired astern, the forward weapons have no ahead fire. For the third armament the 12-pounder gun has been abandoned. There are twenty 3-pounders and eight pompons mounted on the shelter deck. There are three 18-inch torpedo tubes, all submerged, one on either side and one astern.

The propelling machinery will consist of two sets of inverted four-cylinder triple-expansion engines developing 23,500 horse-power and a speed of 22 knots. Steam will be raised from a combination of Babcock & Wilcox water-tube and cylindrical boilers.

One of the features of this new vessel is the placing of the shell rooms in the ammunition passages close to the ammunition hoists, so that a considerable economy in time is effected in obtaining the projectiles for the guns. The ammunition hoists for the 6-inch guns are operated by electric motors, while the hoists for the 9.2-inch guns are worked by hydraulic power.

Owing to the progress that has been made in the utilization of liquid fuel for battleships, the "Black Prince" has been fitted with oil-burning apparatus. The double bottom of the vessel is constructed so as to constitute a reservoir for heavy oil, and is replete with the necessary pumps, pipes, and filters. The maximum coal capacity of the warship is 2,000 tons. The vessel will have a complement of 770 officers and men.

SIMULTANEOUS TELEGRAPHY AND TELEPHONY.*

By JOSEPH HOLLOS.

THE question of simultaneous telegraphy and telephony is not of recent date. While, however, in some places good results have been obtained, in others the advantages reached by this combined using of telephonic circuits are hardly worth mentioning, and in view of the difficulties experienced in the service it was thought preferable to abandon the scheme.

If we look closer at the question we can at once observe that wherever the telegraph and telephone services are under the supervision of one and the same interested person the results obtained are excellent. Where, however, the two systems are in different hands the result is unsatisfactory. Thus, in America, where the financial interest of the telephone companies is involved, because of the desire to increase income by leasing lines for simultaneous telegraphy, and where for this reason these two operations are under the control of one technical staff, the result is excellent. The results are also fair in the European services, if the same technical officer supervises both telegraphy and telephony, and one service is co-ordinated with the other. The result is, on the contrary, very poor in all cases if the telegraph and the telephone services are in different hands.

This is evident if we consider how greatly the one system interferes with the other—that is, that careless handling of the one interferes at once with the proper functioning of the other, the two systems thus being brought into mutual opposition.

For this reason the service must be arranged in such a manner that the two systems cannot interfere with each other, and in so far as troubles are unavoidable, they must be reduced to a minimum. If they should exceed, certain arrangements must be provided to hold out the less important service without delay.

In this direction the Hungarian telegraph and telephone service can show good results by comparison with similar installations, and, therefore, it will not be without interest to outline the principles which were followed in the formation of the system.

Above all, the simultaneous installation must be the simplest possible, because only thus and with the fewest possible instruments may undisturbed working be obtained. For this reason the method of simultaneous working founded on the Wheatstone bridge principle was made the basis of procedure.

The telephone circuit is closed through two inductive branches. At their point of intersection the battery branch is led off to the group of telegraph apparatus, while the telephone apparatus is placed in the so-called galvanometer branch.

It is thus evident that the connecting-in of the telephone apparatus—namely, the leading of the telephone circuit through the switchboard—requires some care, because if there is a ground in the switchboard connections the telegraph working is disturbed. Even if one telephone circuit is directly connected to another, and there be simultaneous working on the latter, the two telegraph simultaneous systems are brought into contact, which again causes marked disturbance. This may also be caused by the operators ringing simultaneously on several circuits from the same common source of ringing current.

Even if only one of the circuits fed from the common ringing source is connected for simultaneous telegraphy, such working will still be slow, because in ringing on the simultaneous conductor we ring also on five or six other conductors. However well insulated these circuits may be individually the insulation of the simultaneous telegraph circuit will be so far reduced by the connection that it will hardly be possible to maintain continuous telegraph working.

It is true that we can remove all these difficulties at one stroke by connecting the incoming telephone circuit, before leading it to the switchboard, to a repeating coil, and working then only on the other half of the repeating coil. But by this plan the difficulty is only transferred to the other side—the telephone side. Above all, we have a loss of energy in the repeating

* A paper presented at Section C of the International Electrical Congress of St. Louis, September 12, 1904.

coil to which are added losses inevitably occurring in the signaling apparatus, and it may happen that with such an arrangement the telephone subscriber does not get as much as 50 per cent of the incoming speaking energy into his receiver. We must strive, therefore, that along with the undisturbed working of the telegraph, the telephone working be kept at the same relative level that would exist in the absence of simultaneous working. Moreover, the repeating coil not only weakens the speaking current but also the calling current, and we must, therefore, take precautions in this direction.

Under these conditions it is inadvisable to connect the circuit first to the repeating coil. As long as the circuit is on the calling apparatus there is no danger of disturbing the simultaneous working. The disturbance arises only at the moment of connecting. For this reason it would be sufficient to place the repeating coil in the connecting cord; but in the same path there is also the clearing-out signal, and a great loss of energy might thus be incurred. This we may, however, remedy if the repeating coil is constructed in such a manner as to serve at the same time as the clearing-out signal.

The clearing-out signal is, as a rule, connected in the bridge between the two branches of the circuit, and its duty is by its great self-induction to prevent the wasting of any considerable part of the speaking current. How far it is able to satisfy this demand might be readily ascertained by inserting a receiver in the joint path. In spite of thus increasing the impedance of the bridge we still obtain intelligible speaking even with a clearing-out signal of 2,000 ohms resistance, if the latter is entirely imbedded in iron. These currents do not so rigidly follow the rules which apply to strong currents, and therefore inferences drawn from such rules do not apply in this case, as may be shown by a simple experiment. With such a clearing-out indicator [illegible] per cent of the energy is lost on the average, and [illegible] per cent only is available, as I have been able to ascertain myself.

With a well-constructed repeating coil, if arranged as a clearing-out signal, the loss is not greater. Consequently, if we insert such a repeating coil into the connecting cord, simultaneous working without affecting the telephone is secured.

The repeating coil transformed into a clearing-out lamp naturally possesses a closed iron circuit. In European practice this plan is avoided and an open-circuit repeating coil is generally preferred. The question whether the repeating coil has an open or closed magnetic circuit does not affect the high frequency involved, and for weak currents this is of much less importance than the other losses that arise in an open-circuit repeating coil.

For relatively strong signaling currents the closed iron circuit is of decided advantage, because with open-circuit repeating coils it is only exceptionally possible to ring through with alternating current, while it is always certain when there is a closed iron circuit.

From the point of view of simultaneous working it only remains to separate the ringing currents.

This may be accomplished if alternators are used by branching the ringing current at each operator's position on a separate repeating coil. Where batteries are used, which are to-day exceptional, each operator's position must be given its separate battery. This is a matter for the technical department.

As for the operating department it is only desirable that the telephone and telegraph operators should be able to communicate with each other quickly, so that they can co-operate in case of troubles.

In the simultaneous working apparatus itself the branching coil is of the highest importance. It is most important that the inductance on the two sides should be equal. This is more important than the exact equality of their ohmic resistance. This, however, determines not only the resistance of the coil but also the size of copper wire to be used.

From the point of view of choking, it is desirable to use long coils; such coils, however, by reason of the phenomena of dispersion, prevent the complete neutralization of the telegraph currents, and, therefore, it is necessary to select short coils. With such an arrangement the operation of the telegraph apparatus is not perceptible on well-balanced telephone circuits.

In the Hungarian telephone system the results hitherto obtained with simultaneous telegraphy and telephony in the manner above described have been excellent.

LIMITATIONS TO THE USE OF STORAGE BATTERIES—AN ENGLISH ENGINEER'S VIEWS.

By H. M. Hobart, M.I.E.E.

Enormous sums have been thrown away upon misdirected storage battery ventures. To a great extent this has been due to overestimating the durability of the batteries under the conditions to which they were to be subjected. An annual depreciation of 6 per cent or less may be attainable with stationary storage batteries, if the current density is low, and expert attendance is provided; but in this case a large initial expenditure is entailed. On the other hand, if the batteries are to be used for moderate speed railway traction, a depreciation of over 300 per cent per year will inevitably result. Figures ranging from one to the other of these limits will be obtained in the various kinds of work for which storage batteries are used; and it is necessary, in order to determine whether a storage battery can be economically employed in any particular case, to estimate the rate of deterioration corresponding to the conditions of use.

The rate of deterioration, and the specific cost of storage batteries, are both considerably higher than is generally realized. An analysis of the practicability of their employment in any given case should proceed from the basis of considering them in the light of a high-priced fuel of high calorific value, rather than as a type of apparatus. The rate of deterioration, as already suggested, cannot be expressed as a time function; it depends upon the many conditions attending the use of the battery in any particular case. An important factor is the number of complete cycles of charge and discharge. Only the very best of the lead batteries will have a life of some 500 complete cycles of charge and discharge; in other words, it will take a very good battery to show a deterioration of less than two-tenths of 1 per cent per cycle. Now, when a stationary battery is only discharged once a week, this would correspond to only 10 per cent depreciation per year; but when, as in automobile cab work, a battery is discharged twice a day or oftener, the battery depreciation will be from 10 to 20 per cent per month.

By approaching matters from this standpoint, it is by no means impossible to determine whether it is, or is not, economically practicable to employ a storage battery in a given case. Nevertheless, it is much more general to argue that storage battery companies have repeatedly undertaken to maintain batteries for 6 per cent per annum, and then, if this rate and the initial outlay do not appear prohibitive, to proceed with the undertaking without further investigation.

By the expensive process of repeated trials, it has now come to be generally recognized that storage batteries can have but a very limited use for tramway and railway work. Such use was often attempted in America some ten to fifteen years ago, and experiments were even made with storage battery traction on the Manhattan Elevated Railway. As early as ten years ago, however, it was, in America, generally conceded that further attempts to employ storage batteries for railway traction work would be futile. Then came a period of activity in Germany, the chief interest centering in the so-called "mixed system," in which trolley cars carried storage batteries to be employed over sections of the line where the trolley wire was considered to be impracticable, on the score of safety, or for æsthetic reasons. The system was for a year or two extensively employed in several large cities in Germany, but was finally abandoned several years ago; for not only was the battery depreciation far in excess of the estimates, but its use on the cars was considered unsanitary.

The most recent, as well as the most elaborate, storage battery installations for traction work were those on certain sections of the Italian railways; at the close of last year these were definitely abandoned. It would be reasonable to suppose that, after such a succession of costly failures, further enterprise on similar lines would be preceded by careful analysis of the data available. Unfortunately, this is hardly likely to be the case. The advent of each new storage battery is heralded by the most exaggerated estimates of its possibilities, and it is generally exploited with but little regard to prior failures and experience.

While there is certainly a legitimate, though limited, field for stationary storage batteries, and probably also for certain classes of automobile work, there is but little reason to expect (pending improvements of the nature of 100 per cent or more), that storage batteries will be successfully employed for tramway and railway traction.

In the following example the figures will purposely be taken more favorable to the storage battery than is justified by present experience.

A single track road, with turnouts, connects two towns 50 kilometers apart. A one-half hour service at an average speed of 50 kilometers per hour is required. The average distance between stops equals 5 kilometers. The traffic will amount to 600 passengers each way per day. Four cars, weighing (complete with battery, motors, and passengers) 40 tons each, will be on the line at any one time; but it will be necessary to provide eight cars, four of which will be either charging, undergoing repairs, or held in reserve. A car will be recharged after each round trip, i. e., the capacity of its storage battery must suffice to carry 40 tons over 100 kilometers at an average speed (including stops) of 50 kilometers per hour. Such a service, assuming a good road, will require at the motors an input of 65 watt-hours per ton-kilometer; or 2.6 kilowatt-hours per kilometer; or 130 kilowatt-hours per car per hour. The average output from the battery must thus be equal to 130 kilowatts. Let the voltage be 250 volts; current, 520 amperes. The battery must be able to give an average of 520 amperes during the round trip of 100 kilometers, i. e., during two hours; it must, therefore, have a capacity of 1,040 ampere-hours. It will be assumed that the standard Edison cell will be employed. This cell, at its 75 ampere discharge rate, has a capacity of 150 ampere-hours, thus giving 75 amperes for two hours. Its discharge voltage may be taken at 1.2 volts. Two hundred and eight such cells in series, and 7 in parallel, or 1,456 total cells per car, would be required. Each cell weighs 8 kilogrammes. The battery of 1,456 cells weighs 11.6 tons. Taking the low price of 4.5 shillings per kilogramme, the initial cost of the battery would be £2,600. The car would make its round trip of 100 kilometers in two hours; it would then be recharged, its place being taken by another car. The recharging would be at the rate of 150 amperes per cell, and it could again be placed in service in one hour. Thus it requires three hours for a car to make its round trip and be recharged. Each car would make five round trips per day, or travel 500 kilometers per day. The experience with lead batteries, on the Italian railways, showed a life of 12,000 train-kilometers for the positive, and 20,000 train-kilometers for the negative plates. It would appear ill-advised, pending experimental investigations, to assume an ultimate life for the Edison cell of over 60,000 kilometers, i. e., three times the life of the negatives of the lead cell. A life of 60,000 car-kilometers corresponds to 100 per cent depreciation in 120 days. Hence three battery equipments must be supplied annually. Annual outlay for storage battery per car $= 3 \times 2{,}600 = £7{,}800$. This item is to be treated as coal would be for a locomotive. But there is a further expenditure for electrical energy in charging the battery. This may be determined as follows:

The battery delivers to the motors 2.6 kilowatt-hours per car kilometer; or 1,300 kilowatt-hours per car day. The energy efficiency, when charging at 1,040 amperes and discharging at 520 amperes, will be just about 50 per cent. Hence each car will require a daily charge of 2,600 kilowatt-hours. At 1d. per kilowatt-hour, this amounts to £10 16s. per car per day, or to £3,950 per car per annum.

Annual outlay for providing storage batteries for six cars*	£46,800
Annual outlay for providing storage batteries for two spare cars†	5,200
Annual outlay for charging six cars........	23,700
Total annual outlay for eight cars on account of storage battery	£75,700

A 40-ton car costs, including motors and air brakes, but exclusive of battery, about £1,200; depreciation = 12 per cent.

The roadbed, track construction, and buildings, would come to about £1,500 per kilometer; depreciation = 3 per cent.

Capital expenditure for eight cars..........	£9,600
Capital expenditure for roadbed, track construction, and buildings	75,000
Total capital expenditure	£84,600
Interest at 5 per cent	4,240

ANNUAL COST.

Interest on capital expenditure.............	£4,240
All storage battery outlays per annum......	75,700
Depreciation on rolling stock, permanent way, and buildings	2,900
Taxes and traffic and administration expenses	5,000
Total annual charges	£87,840

of which 86.6 per cent falls on the storage battery expenditures.

This line will carry 600 passengers each way per day, which makes a total traffic of 60,000 passenger-kilometers per day, or 21,900,000 passenger-kilometers per year.

To meet the total annual charges, this traffic must yield $87{,}840 \times 240 = 21{,}000{,}000$d., which would require a fare of 0.96d. per kilometer, or 1.54d. per mile. To give a fair margin for contingencies and profits, a fare of at least 2d. per mile would be necessary.

The traffic may also be expressed in car-kilometers, and amounts to 3,000 car-kilometers per day; or 20 passengers per car. As such a car would seat some 80 passengers, it is obvious that the load factor of the car (25 per cent) is as high as could safely be assumed, and that a heavier traffic would require more cars. But as over 90 per cent of the charges are for the cars and the storage batteries, a more frequent service would bring no remedy.

The low efficiency of 50 per cent which has been assumed, may occasion surprise. It is taken from the published tests of the Edison battery. A higher efficiency could only be obtained by carrying a greater weight of battery, operated at a low current density. This would obviously lead to still higher costs.

A considerably higher efficiency could be obtained with the lead cell. As we have seen, however, its positives would have but one-fifth, and the negatives but one-third the life assumed for the Edison cell; or, say, an average life one-fourth as great. Hence, on the road in question, a new battery would be required once per month. The lead battery would be somewhat heavier, but on the other hand would cost but one-third as much per kilogramme; i. e., some 1.5 shillings per kilogramme, as against at least 4.5 shillings per kilogramme for the Edison cell. It is evident that these diverse properties of the two types of cell approximately offset one another, and the economic practicability is about the same in the two cases.

It is not so much with a view to the tramway question that this comparison is of value, as it is to emphasize the difficulties attending the use of electricity on automobiles. If electric automobiles are successfully introduced, it will be in the face of difficulties of the same nature as those revealed in the above analysis.

The estimation of the cost for automobile work cannot be made with much precision. The results of one of the most recent estimations (see The Electrician for June 3, 1904, p. 268) for heavy slow-speed delivery wagons, which offer the best conditions for the storage battery, were as follows:

The wagons weigh one ton apiece, cost £500, and cover 30 miles (48 kilometers) per day in commercial service in New York city. After 95 days (4,300 kilometers) the battery requires elaborate cleaning, which

* Three batteries per car per year.
† One battery per car per year.

necessitates cutting all the connecting straps, washing the mud from the plates and the jars, and reconnecting the cells. After another 75 days (3,400 kilometers), a second overhauling is required, and some replacement of parts. After a further 60 days (2,700 kilometers), the positive plates are replaced, their total life having been 10,400 kilometers; about the same result as was obtained on the Italian railways (12,000 kilometers). It is stated that the negatives have an average life equal to 1 2-3 that of the positives, here again confirming the experience in Italy.

The total annual outlay per wagon, for upkeep of battery, works out at £81, and a further £24 per annum is expended in charging the battery.

Thus the total outlay for battery is £105 per wagon per annum; tire maintenance, £36 per annum; repairs and depreciation of wagon, £51 per annum; interest on investment, £25 per annum; total cost per annum = £217.*

The wagon covers 13,900 kilometers per year. The cost is thus 3.7d. per wagon kilometer, and also per ton kilometer. In the railway instance, which we worked out, the cost comes to 0.48d. per ton kilometer; for although the speed is some four times higher, there is greater economy per ton due to the forty times heavier car, and due to the better traction conditions on rails. Thus a similar analysis for a 5-ton delivery wagon shows a cost of but 2.7d. per ton kilometer. The New York one-ton delivery wagon requires an input to the battery of 300 watt-hours per ton kilometer. This high value is due to its small weight, the frequent stops, and the high tractive effort required on city streets.

Even for stationary work, the writer is of the opinion that in at least 75 per cent of the cases where storage batteries are employed, an analysis of the costs would show that greater economy could be obtained in other ways. Stationary storage batteries for central stations and sub-stations generally consist of cells weighing up to 140 kilogrammes each. These, when of the lead type, cost something like 6d. per kilogramme—about one-third the cost of the smaller cells employed in automobile work. Nevertheless, a careful analysis rarely shows any economy to be attainable over alternative methods, by the use of storage batteries.—Technics.

* This estimate does not include administration expenses, taxes, etc.

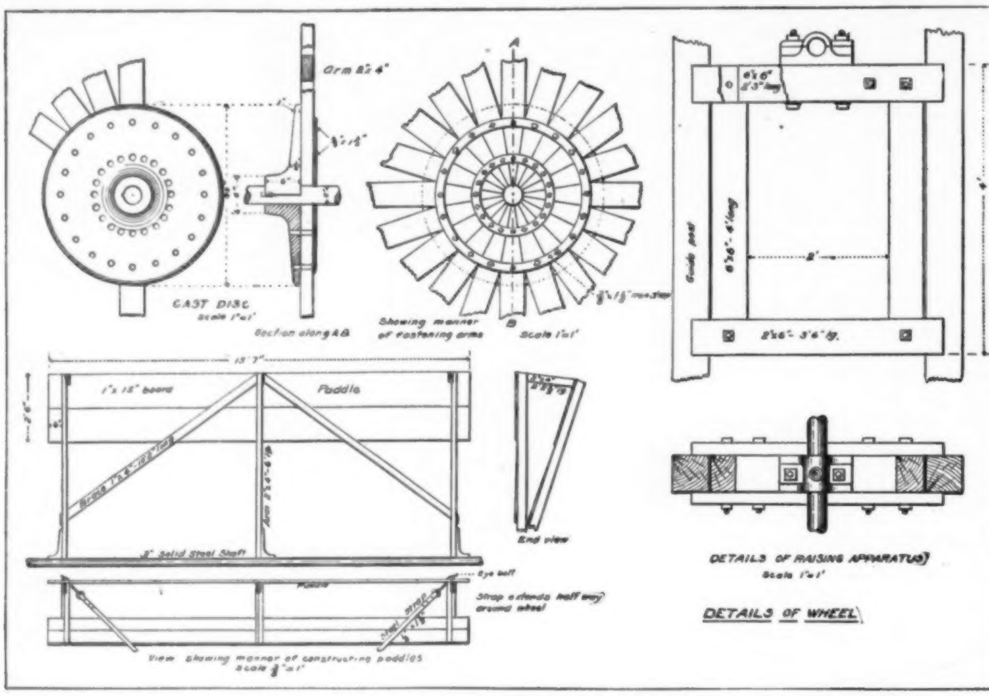


Fig. 18.—CURRENT WHEEL OPERATING PUMP IN PAYETTE VALLEY, IDAHO.

[Concluded from Supplement No. 1511, page 24217.]

CURRENT WHEELS: THEIR USE IN LIFTING WATER FOR IRRIGATION.*

Wheels for Running Pumps.

A wheel operating a rotary pump is shown in Plate V. It is in use in the Yakima River, near Prosser, Wash. It is home-made, but a fine example of a cheap, serviceable wheel. Being suspended between two heavy timbers anchored in the banks, no expensive pier is required. The wheel is 11 feet in diameter and 17.5 feet long. The paddles are 2 feet wide of 1-inch stuff. The whole wheel is easily raised and lowered by one man by means of double pulleys and a windlass with long spokes, seen to the left of the center of the picture.

The main driving pulley is nailed to the spokes of the wheel, and is 7 feet in diameter. A 1½-inch rope runs over this pulley, carrying the power to a 28-inch pulley on a countershaft. The driver on the countershaft is 10 feet in diameter and is connected by a ⅞-inch rope to a pulley at the pump, which can be adjusted from 11 inches to a larger size, as speed requires. The pump shaft revolves 32 times to each revolution of the water wheel. The pump raises water 48 feet, and at full speed discharges one-third of a cubic foot per second. When the river is low, much less is pumped.

The cost of the wheel was $40 to $50 for materials, or, counting the owner's time in construction, say $70 to $75. Of this cost $20 was for a steel shaft. The cost of the pump was not given, but was probably $75 to $85. The entire plant may have cost $200. It successfully irrigates eighteen acres in fruit and alfalfa, the land being valued at $20 per acre. The annual expense for rope, oil, and repairs is nearly $20.

In the lower Payette Ditch, in Idaho, are eight wheels, used to run pumps. One of these plants is here described as an example of a well-built and expensive outfit, which is, however, eminently successful. The plan and construction of the wheel are shown in Figs. 18 and 19. The wheel is connected by chain and sprocket to a three-piston, 5-inch pump, which forces the water through 1,800 feet of 4¾-inch pipe to the upper side of the owner's ranch, 30 feet above the canal. The pump has three parallel pistons connected to eccentrics on the same shaft, so arranged that each piston in turn comes into action. The cost of the plant was as follows:

5-inch triple action pump	$165
3-inch steel shaft, 18 feet long	35
3 cast-iron flanges, 3 feet diameter	30
2 boxings for main shaft	8
Cast-iron sprocket, gear wheels, and chains	115
Lumber	60
1,800 feet of 4¾-inch galvanized-iron pipe	274
Labor	50
Total	$737

Of this cost only about $120 is for the wheel. No attention other than daily oiling is required. As the plant was put in in 1903, no repairs have as yet been necessary. The annual cost for maintenance should fall below $10.

The amount of water raised is about 0.3 cubic foot per second, which is used to irrigate twenty-seven acres in fruit. Water is applied 145 days, making the total depth of irrigation in the season almost exactly 3 feet. The orchard of 2,500 young trees—prunes, apples, and pears—should, when older, yield an annual crop worth $5,000.

Chain-and-Bucket Gears.

A water elevator of the chain-and-bucket type is shown in Plate VI. It is run by a 5-foot overshot wheel of ordinary construction, but since it is equally adaptable to current wheels, it is of interest in their discussion. The elevator consists of two endless chains running over sprocket wheels, each chain carrying twelve galvanized-iron buckets, as shown in illustration. The lower sprocket wheels are 32 inches in diameter, set on a 3-inch shaft. The upper sprockets are 21 inches in diameter on a 1⅝-inch shaft. The sprockets are set 18 inches apart and the distance between shafts is 20 feet. The cost of the outfit was given as about $250. Of this amount the chain cost $75 and the buckets $20. Estimating the four sprocket wheels at $10 each, the two shafts at $12.50, and the four boxings at $4.50 each, the cost of the lifting apparatus without the wheel was about $145. The owner found No. 77 chain too light and recommended heavy gear throughout for the constant service required.

Plate V.—WHEEL OPERATING A ROTARY PUMP, YAKIMA RIVER, WASHINGTON.

A simple application of chain-and-bucket gear to current wheels is suggested in Fig. 21. The power is transmitted by a rope to one of the shafts—in this case the lower one. This arrangement makes it easy to place the whole apparatus near the bank of a stream, or, if desired, the elevator could be placed at any convenient distance.

* Bulletin 146 of the United States Dept. of Agriculture.

Italian Current Wheels.

Two wheels on opposite sides of the swift Adige River in Italy, just above the city of Verona, are 50 feet in height, raising water 40 feet. The construction is the lightest possible owing to scarcity of wood in that region, the spokes being light single poles braced by two sets of still lighter strips. The rim is a continuous wooden box divided into compartments, each with a sort of trap door which opens when entering the water and closes of itself as it begins to rise. To this box or rim the paddles are fastened on either side, being nailed to cleats. They are braced at the ends by slender sticks run through holes bored in the paddles and keyed or wedged in place. It is usual to arrange two wheels with a flume between them, though the advantage of this arrangement is not evident. A wing dam turns the current into a flume running under the wheel.

A floating current wheel also in the Adige River is used for operating a grist mill.

A typical modern current wheel in Milan, Italy, is used for power. The curved blades are made of sheet iron, the entire framework being of steel. The water runs swiftly down a sluice striking only the tips of the blades. Owing to their curvature, it slides smoothly up the blades, comes to rest, and is discharged with very little velocity. An offset in the tailrace just below the wheel provides ample waste way.

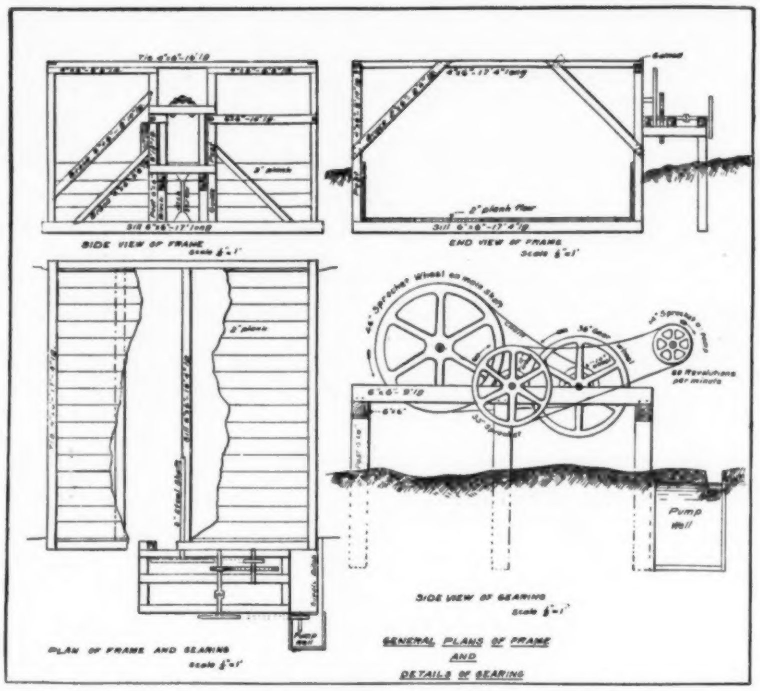


FIG. 19.—FRAMING AND GEARING FOR WHEEL SHOWN IN FIG. 18.

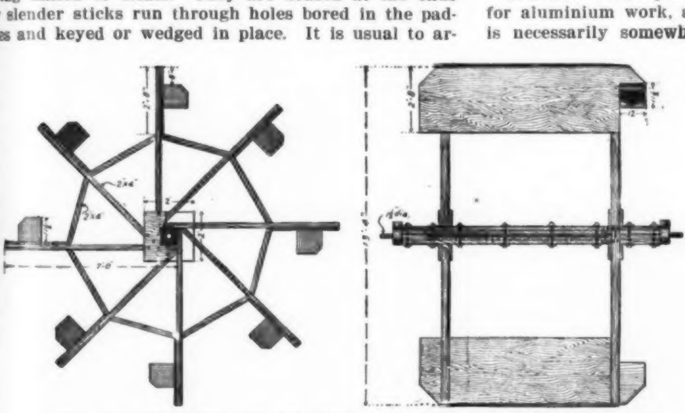


FIG. 20.—WHEEL IN YAKIMA VALLEY, WASHINGTON.

FIG. 21.—CHAIN AND BUCKET OPERATED BY CURRENT WHEEL.

PLATE VI.—CHAIN AND BUCKET OPERATED BY OVERSHOT WHEEL, SELAH, WASH.

MAKING CASTINGS IN ALUMINIUM.

THE method adopted in preparing molds and cores for aluminium work, according to Practical Engineer, is necessarily somewhat the same as for brass, but there are particular points which need attention to insure successful work. Both in the sand and the making of the molds there are some small differences which make considerable variation in the results, and the temperature at which the metal is poured is a consideration of some importance.

In selecting the sand, which should not have been previously used, that of a fine grain should be chosen, but it should not have any excess of aluminous matter, or it will not permit of the free escape of gases and air, this being an important matter. Besides this, the sand must be used as dry as possible consistent with its holding against the flow of the metal, and having only moderate compression in ramming.

In making the molds it is necessary to remember that aluminium has a large contraction in cooling, and also that at certain temperatures it is very weak and tears readily, while all metals shrink away from the mold when this is wholly outside the casting, but they shrink on to cores or portions of the mold partly inclosed by metal. Thus, if casting a plate or bar of metal, it will shrink away from the mold in all directions; but if casting a square frame, it shrinks away from the outside only, while it shrinks on to the central part or core. With brass, or iron, or such metals, this is not of much importance, but with some others, including aluminium, it is of great importance, because if the core or inclosed sand will not give somewhat with the contraction of the metal, torn or fractured castings will be the result. Both for outside and inside molds, and with cores used with aluminium, the sand should be compressed as little as possible, and hard ramming must in every case be avoided, particularly where the metal surrounds the sand. The molds must be very freely vented, and not only at the joint of the mold, but by using the vent wire freely through the body of the mold itself; in fact, for brass the venting would be considered excessive. With aluminium it is, however, necessary to get the air off as rapidly as possible, because the metal soon gets sluggish in the mold, and unless it runs up quickly it runs faint at the edges. The ingates should be wide and of fair area, but need careful making to prevent them drawing where they enter the casting, the method of doing this being known to most molders.

If it is considered desirable to use a specially made-up facing sand for the molds where the metal is of some thickness, the use of a little pea or bean meal will be all that is necessary. To use this, first dry as much sand as may be required and pass through a 20-mesh sieve, and to each bushel of the fine sand rub in about 4 quarts of meal, afterward again passing through the sieve to insure regular mixing. This sand should then be damped as required, being careful that all parts are equally moist, rubbing on a board being a good way to get it tough, and in good condition, with the minimum of moisture.

The molds should not be sleeked with tools, but they may be dusted over with plumbago or steatite, smoothing with a camel's hair brush, in cases where a very smooth face is required on the castings. Preferably, however, the use of the brush even should be avoided. Patterns for aluminium should be kept smooth and well varnished, as the better the face of

the pattern the smoother the mold is left, as a rule, a point worthy of consideration in relation to the making of molds for casting all kinds of metals and alloys.

In melting the metal it is necessary to use a plumbago crucible which is clean, and which has not been used for other metals. Clay or silica crucibles are not good for this metal, especially silica, on account of the metal absorbing silicon and becoming hard under some conditions of melting. A steady fire is necessary, and the fuel should reach only about half way up the crucible, as it is not desirable to overheat the crucible or metal. The metal absorbs heat for some time and then fuses with some rapidity, hence the desirability of a steady heat; and as the metal should be poured when of a claret color under the film of oxide which forms on its surface, too rapid a heating is not advisable. The molding should always be well in advance of the pouring, because the metal should be used as soon as it is ready; for not only is waste caused, but the metal loses condition if kept in a molten state for long periods. The metal should be poured rapidly, but steadily, and when cast up there should not be a large head of metal left on top of the runner. In fact, it is rather a disadvantage to leave a large head, as this tends to draw rather than to feed the casting.

With properly prepared molds, and careful melting, fluxes are not required, but ground cryolite—a fluoride of sodium and aluminium—is sometimes used to increase the fluidity of the metal. In using this, a few ounces according to the bulk of metal to be treated is put into the molten metal before it is taken from the furnace, and well stirred in, and as soon as the reaction apparently ceases the pot is lifted and the metal at once skimmed and poured. The use of sodium in any form with aluminium is very undesirable, however, and should be avoided, and the same remark applies to tin, but there is no objection to alloying with zinc, when the metal thus produced is sold as an alloy.

Aluminium also casts very well in molds of plaster of Paris and crushed bath brick when such molds are perfectly dry and well vented, smoothness being secured by brushing over with dry steatite or plumbago. When casting in metal molds, these should be well brushed out with steatite or plumbago, and made fairly hot before pouring, as in cold molds the metal curdles and becomes sluggish, with the result that the castings run up faint.

[Continued from Supplement No. 1511, page 24215.]

NORTH POLAR EXPLORATION: FIELD WORK OF THE PEARY ARCTIC CLUB, 1898-1902.*

By Commander R. E. Peary, United States Navy.

1899-1900.

The "Diana" seemed to have gathered in and taken with her all the fine weather, leaving us a sequence of clouds, wind, fog, and snow, which continued with scarcely a break for weeks.

After her departure the work before me presented itself in its own natural sequence as follows: Protect the provisions, construct our winter quarters, then begin building sledges and grinding walrus meat for dog pemmican for the spring campaign.

During the first month a number of walrus were killed from our boats off the mouth of the fjord; then the usual Arctic winter settled down upon us, its monotony varied only by the visits of the natives, occasional deer hunts, and a December sledge journey to the Eskimo settlements in Whale Sound as far as Kangerd-looksoah. In this nine-days' trip some 240 miles were covered in six marches, the first and the last marches being 60 to 70 miles. I returned to Etah just in time to escape a severe snow-storm, which stopped communication between Etah and the other Eskimo settlements completely until I sent a party with snowshoes and a specially constructed sledge, carrying no load, and manned by a double team of dogs, to break the trail.

During my absence some of my natives had crossed to Mr. Stein's place at Sabine, and January 9 I began the season's work by starting a few sledge loads of dog food for Cape Sabine, for use of my teams in the spring journey. From this time on, as the open water in Smith Sound permitted, more dog food was sent to Sabine, and as the light gradually increased, some of my Eskimos were kept constantly at Sonntag Bay, some twenty miles to the south, on the lookout for walrus.

My general programme for the spring work was to send three divisions of sledges north as far as Conger, the first to be in charge of Henson, while I brought up the rear with the third.

From Conger I should send back a number of Eskimos, retain some at Conger, and with others proceed north from there either via Hecla or the north point of Greenland, as circumstances might determine.

I wanted to start the first division on the 15th of February, the second a week later, and leave with the third March 1, but a severe storm, breaking up the ice between Etah and Littleton Island, delayed the departure of the first division of seven sledges until the 19th.

The second division of six sledges started on the 26th, and March 4 I left with the rear division of nine sledges. Three marches carried us to Cabe Sabine, along the curving northern edge of the north water. Here a northerly gale with heavy drift detained me for two days. Three more marches in a temperature of —40 deg. F., brought me to the house at Cape D'Urville. Records here informed me that the first division had been detained here a week by stormy weather, and the second division had left but two days before my arrival. I had scarcely arrived when two of Henson's Eskimos came in from Richardson Bay, where one of them had severely injured his leg by falling under a sledge. One day was spent at the D'Urville house drying our clothing, and on the 13th I got away on the trail of the other divisions with seven sledges, the injured man going to Sabine with the supporting party.

I hoped to reach Cape Louis Napoleon on this march, but the going was too heavy, and I was obliged to camp in Dobbin Bay, about five miles short of the cape.

The next day I hoped on starting to reach Cape Fraser, but was again disappointed, a severe windstorm compelling me to halt a little south of Hayes Point, and hurriedly build snow igloos in the midst of a blinding drift.

All that night and the next day and the next night the storm continued. An early start was made on the 16th, and in calm but very thick weather we pushed on to Cape Fraser. Here we encountered the wind and drift full in our faces and violent, making our progress from here to Cape Norton Shaw along the ice-foot very trying.

The going from here across Scoresby and Richardson bays was not worse than the year before; and from Cape Wilkes to Cape Lawrence the same as we had always found it. These two marches were made in clear but bitterly windy weather.

Another severe southerly gale held us prisoners at Cape Lawrence for a day. The 20th was an equally cruel day, with wind still savage in its strength, but the question of food for my dogs gave me no choice but to try to advance. At the end of four hours we were forced to burrow into a snow bank for shelter, where we remained till the next morning.

In three more marches we reached Cape von Buch. Two more days of good weather brought us to a point a few miles north of Cape Defosse. Here we were stopped by another furious gale with drifting snow, which prisoned us for two nights and a day.

The wind was still bitter in our faces when we again got under way the morning of the 27th. The ice-foot became worse and worse up to Cape Cracroft, where we were forced down into the narrow tidal joint at the base of the ice-foot; this path was a very narrow and tortuous one, frequently interrupted, and was extremely trying on men and sledges. Cape Lieber was reached on this march. At this camp the wind blew savagely all night, and in the morning I waited for it to moderate before attempting to cross Lady Franklin Bay.

While thus waiting, the returning Eskimos of the first and second divisions came in. They brought the very welcome news of the killing of twenty-one musk oxen close to Conger. They also reported the wind out in the bay as less severe than at the cape.

I immediately got under way and reached Conger just before midnight of the 28th, twenty-four days from Etah, during six of which I was held up by storms.

The first division had arrived four days and the second two days earlier. During this journey there had been the usual annoying delays of broken sledges, and I had lost numbers of dogs.

The process of breaking in the tendons and muscles of my feet to their new relations, and the callousing of the amputation scars, in this, the first serious demand upon them, had been disagreeable, but was, I believed, final and complete. I felt that I had no reason to complain.

The herd of musk oxen so opportunely secured near the station, with the meat cached here the previous spring, furnished the means to feed and rest my dogs. A period of thick weather followed my arrival at Conger, and not until April 2 could I send back the Eskimos of my division.

On leaving Etah I had not decided whether I should go north from Conger *via* Cape Hecla, or take the route along the northwest coast of Greenland. Now I decided upon the latter. The lateness of the season and the condition of my dogs might militate against a very long journey, and if I chose the Hecla route and failed of my utmost aims the result would be complete failure. If, on the other hand, I chose the Greenland route and found it impossible to proceed northward over the pack, I still had an unknown coast to exploit, and the opportunity of doing valuable work. Later developments showed my decision to be a fortunate one.

I planned to start from Conger the 9th of April, but stormy weather delayed the departure until the 11th, when I got away with seven sledges.

At the first camp beyond Conger my best Eskimo was taken sick, and the following day I brought him back to Conger, leaving the rest of the party to cross the channel to the Greenland side, where I would overtake them. This I did two or three days later, and we began our journey up the northwest Greenland coast. As far as Cape Sumner we had almost continuous road making through very rough ice. Before reaching Cape Sumner we could see a dark water sky, lying beyond Cape Brevoort, and knew that we should find open water there.

From Cape Sumner to Polaris Boat Camp, in Newman Bay, we cut a continuous road. Here we were stalled until the 21st by continued and severe winds. Getting started again in the tail end of the storm, we advanced as far as the open water, a few miles east of Cape Brevoort, and camped. This open water, about three miles wide at the Greenland end, extended clear across the mouth of Robeson Channel to the Grinnell Land coast, where it reached from Lincoln Bay to Cape Rawson. Beyond it to the north and northwest as far as could be seen were numerous lanes and pools. The next day was devoted to hewing a trail along the ice-foot to Repulse Harbor, and on the 23d, in a violent gale accompanied by drift, I pushed on to the "Drift Point" of Beaumont (and later Lockwood), a short distance west of Black Horn Cliffs.

The ice-foot as far as Repulse Harbor, in spite of the road making of the previous day, was very trying to sledges, dogs and men. The slippery side slopes, steep ascents, and precipitous descents wrenched and strained the latter, and capsized, broke, and ripped shoes from the former.

I was not surprised to see from the "Drift Point" igloo that the Black Horn Cliffs were fronted by open water. The pack was in motion here, and had only recently been crushing against the ice-foot, where we built our igloo. I thought I had broken my feet in pretty thoroughly on my journey from Etah to Conger, but this day's work of handling a sledge along the ice-foot made me think they had never encountered any serious work before. A blinding snowstorm on the 24th kept us inactive. The next day I made a reconnoissance to the cliffs, and the next day set the entire party to work hewing a road along the ice-foot. That night the temperature fell to —25 deg. F., forming a film of young ice upon the water. The next day I moved up close to the cliffs, and then with three Eskimos reconnoitered the young ice. I found that by proceeding with extreme care it would in most places support a man.

With experienced Ahsayoo ahead constantly testing the ice with his seal spear, myself next, and two Eskimos following, all with feet wide apart, and sliding instead of walking, we crept past the cliffs. Returning we brushed the thin film of newly fallen snow off the ice with our feet for a width of some four feet, to give the cold free access to it.

I quote from my diary for the 27th:

"At last we are past the barrier, which has been looming before me for the last ten days, the open water at the Black Horn Cliffs. Sent two of my men whose nerves are disturbed by the prospect ahead, back to Conger. This leaves me with Henson and three Eskimos. My supplies can now be carried on the remaining sledges. Still further stiffened by the continuous low temperature of the previous night, the main sheet of new ice in front of the cliffs was not hazardous as long as the sledges kept a few hundred feet apart, did not stop, and their drivers kept some yards away to one side. Beyond the limit of my previous day's reconnoissance there were areas of much younger ice, which caused me considerable apprehension, as it buckled to a very disquieting extent beneath dogs and sledges, and from the motion of the outside pack was crushed up in places while narrow cracks opened up in others. Finally, to my relief, we reached the ice-foot beyond the cliffs and camped."

The next day there was a continuous lane of water 100 feet wide along the ice-foot by our camp, and the space in front of the cliffs was again open water. We crossed just in time.

Up to Cape Stanton we had to hew a continuous road along the ice-foot. After this the going was much better to Cape Bryant. Off this section of the coast the pack was in constant motion, and an almost continuous lane of water extended along the ice-foot. A little west of Cape Bryant I killed two musk oxen, the flesh of which my dogs highly appreciated. A long search at Cape Bryant finally discovered the remains of Lockwood's cache and cairn, which had been scattered by bears. At 3:30 P. M. the 1st of May I left Cape Bryant to cross the wide indentation lying between Cape Bryant and Cape Britannia. Three marches, mostly in thick weather and over alternating hummocky blue ice and areas of deep snow, brought us at 1 A. M. of the 4th to Cape North (the northern point of Cape Britannia Island). From this camp, after a sleep, I sent back two more Eskimos and the twelve poorest dogs, leaving Henson, one Eskimo, and myself with three sledges and sixteen dogs fo the permanent advance party.

From Cape North, a ribbon of young ice, on the so-called tidal crack which extends along this coast, gave us a good lift nearly across Nordenskjold Inlet. Then it became unsafe, and we climbed a heavy rubble barrier to the old floe ice inside, which we followed to Cape Benet and camped. Here we were treated to another snowstorm.

Another strip of young ice gave us a passage nearly across Mascart Inlet until, under Cape Payer, I found it so broken up that two of the sledges and nearly all of the dogs got into the water before we could escape from it. Then a pocket of snow, thigh and waist deep over rubble ice under the lee of the cape stalled us completely. I pitched the tent, fastened the dogs, and we devoted the rest of the day to stamping a road through the snow with our snowshoes. Even then when we started the next day, I was obliged to put two teams to one sledge in order to move it.

Cape Payer was a hard proposition. The first half of the distance round it we were obliged to cut a road, and on the last half, with twelve dogs and three men to each sledge to push and pull them, snow-plow fashion, through the deep snow.

* From manuscript, as read before the Peary Arctic Club, by courtesy of the National Geographic Society, and reprinted in Smithsonian Institution Report.

Distant Cape was almost equally inhospitable, and it was only after long and careful reconnoissance that we were able to get our sledges past along the narrow crest of the huge ridge of ice forced up against the rocks. After this we had comparatively fair going on past Cape Ramsay, Dome Cape, and across Meigs Fjord, as far as Mary Murray Island. Then came some heavy going, and at 11:40 P. M. of May 8 we reached Lockwood's cairn on the north end of Lockwood Island. From this cairn I took the record and thermometer deposited there by Lockwood eighteen years before. The record was in a perfect state of preservation.

One march from here carried us to Cape Washington. Just at midnight we reached the low point, which is visible from Lockwood Island, and great was my relief to see, on rounding this point, another splendid headland, with two magnificent glaciers debouching near it, rising across an intervening inlet. I knew now that Cape Washington was not the northern point of Greenland, as I had feared. It would have been a great disappointment to me, after coming so far, to find that another's eyes had forestalled mine in looking first upon the coveted northern point.

Nearly all my hours for sleep at this camp were taken up by observations and a round of angles. The ice north from Cape Washington was in a frightful condition, utterly impracticable. Leaving Cape Washington, we crossed the mouth of the fjord, packed with blue-top floe bergs, to the western edge of one of the big glaciers, and then over the extremity of the glacier itself, camping near the edge of the second. Here I found myself in the midst of the birthplace of the "floe bergs," which could be seen in all the various stages of formation. These floe bergs are merely degraded icebergs, that is, bergs of low altitude, detached from the extremity of a glacier, which has for some distance been forcing its way along a comparatively level and shallow sea bottom.

From this camp we crossed the second glacier, then a small fjord, where our eyes were gladdened by the sight of a polar bear, which a couple of bullets from my carbine quickly transformed into dog meat for my faithful teams. The skin of this bear I have brought back as a trophy for the club.

It was evident to me now that we were very near the northern extremity of the land, and when we came within view of the next point ahead, I felt that my eyes rested at last upon the Arctic Ultima Thule (Cape Morris Jesup). The land ahead also impressed me at once as showing the characteristics of a musk-ox country.

This point was reached in the next march, and I stopped to take variation and latitude sights. Here my Eskimo shot a hare, and we saw a wolf track and traces of musk oxen. A careful reconnoissance of the pack to the northward, with glasses, from an elevation of a few hundred feet, showed the ice to be of a less impracticable character than it was north of Cape Washington. What was evidently water clouds showed very distinctly on the horizon. This water sky had been apparent ever since we left Cape Washington, and at one time assumed such a shape that I was almost deceived into taking it for land. Continued careful observation destroyed the illusion. My observations completed, we started northward over the pack, and camped a few miles from land.

The two following marches were made in a thick fog, through which we groped our way northward over broken ice and across gigantic, wave-like drifts of hard snow. One more march in clear weather over frightful going, consisting of fragments of old floes, ridges of heavy ice thrown up to heights of 25 to 50 feet, crevasses and holes masked by snow, the whole intersected by narrow leads of open water, brought us at 5 A. M., on the 16th, to the northern edge of a fragment of an old floe bounded by water. A reconnoissance from the summit of a pinnacle of the floe, some 50 feet high, showed that we were on the edge of the disintegrated pack, with a dense water sky not far distant.

My hours for sleep at this camp were occupied in observations, and making a transit profile of the northern coast from Cape Washington eastward.

The next day I started back for the land, and having a trail to follow, and no time wasted in reconnoissance, reached it in one long march, and camped.

Leaving this camp on the 18th, as we were traveling eastward on the ice-foot an hour later, I saw a herd of six musk oxen in one of the coast valleys, and in a short time had secured them. Skinning and cutting up these animals and feeding the dogs to repletion consumed some hours, and we then resumed our march, getting an unsuccessful shot at a passing wolf as we went.

Within a mile of our next camp a herd of fifteen musk oxen lay fast asleep; I left them undisturbed. From here on, for three marches, we reeled off splendid distances, over good going, in blinding sunshine, and in the face of a wind from the east which burned our faces like a sirocco.

The first march took us to a magnificent cape (Cape Bridgman), at which the northern face of the land trends away to the southeast. This cape is in the same latitude as Cape Washington. The next two carried us down the east coast to the eighty-third parallel. In the first of these we crossed the mouth of a large fjord penetrating for a long distance in a southwesterly (true) direction. On the next, in a fleeting glimpse through the fog, I saw a magnificent mountain of peculiar contour which I recognized as the peak seen by me in 1895 from the summit of the interior ice cap south of Independence Bay, rising proudly above the land to the north. This mountain was then named by me Mount Wistar. Finally, the density of the fog compelled a halt on the extremity of a low point, composed entirely of fine glacial drift, and which I judged to be a small island in the mouth of a large fjord.

From my camp of the previous night I had observed this island (?) and beyond and over it a massive block of a mountain, forming the opposite cape of a large intervening fjord, and beyond that again another distant cape. Open water was clearly visible a few miles off the coast, while, not far out, dark water clouds reached away to the southeast.

At this camp I remained two nights and a day, waiting for the fog to lift. Then, as there seemed to be no indication of its doing so, and my provisions were exhausted, I started on my return journey at 3:30 A. M. on the 22d of May, after erecting a cairn, in which I deposited the following record:

"COPY OF RECORD IN CAIRN AT CLARENCE WYCKOFF ISLAND.

"Arrived here at 10:30 P. M., May 20, from Etah via Fort Conger and north end of Greenland. Left Etah March 4. Left Conger April 15. Arrived north end of Greenland May 13. Reached point on sea ice latitude 83 deg. 50 min. north May 16.

"On arrival here had rations for one more march southward. Two days dense fog have held me here. Am now starting back.

"With me are my man, Mathew Henson; Ahngmalokto, an Eskimo; sixteen dogs, and three sledges.

"This journey has been made under the auspices of, and with the funds furnished by, the Peary Arctic Club of New York City.

"The membership of this club comprises Morris K. Jesup, Henry W. Cannon, Herbert L. Bridgman, John H. Flagler, E. C. Benedict, James J. Hill, H. H. Benedict, Fredk. E. Hyde, E. W. Bliss, H. H. Sands, J. M. Constable, C. F. Wyckoff, E. G. Wyckoff, Chas. P. Daly, Henry Parish, A. A. Raven, G. B. Schley, E. B. Thomas, and others.

"(Signed) R. E. Peary,
"Civil Engineer, U. S. N."

The fog kept company with us on our return almost continuously until we had passed Lockwood Island, but, as we had a trail to follow, did not delay us so much as the several inches of heavy snow that fell in a furious arctic blizzard, which came rushing in from the polar basin and imprisoned us for two days at Cape Bridgman.

At Cape Morris K. Jesup, the northern extremity, I erected a prominent cairn, in which I deposited the following record:

"COPY OF RECORD IN NORTH CAIRN.

"May 13, 1900—5 A. M.—Have just reached here from Etah via Fort Conger. Left Etah March 4. Left Conger April 15. Have with me my man, Henson; an Eskimo, Ahngmalokto; sixteen dogs, and three sledges; all in fair condition. Proceed to-day due north (true) over sea ice. Fine weather. I am doing this work under the auspices of, and with funds furnished by, the Peary Arctic Club of New York City.

"The membership of this club comprises Morris K. Jesup, Henry W. Cannon, Herbert L. Bridgman, John H. Flagler, E. C. Benedict, Fredk. E. Hyde, E. W. Bliss, H. H. Sands, J. M. Constable, C. F. Wyckoff, E. G. Wyckoff, Chas. P. Daly, Henry Parish, A. A. Raven, E. B. Thomas, and others.

"(Signed) R. E. Peary,
"Civil Engineer, U. S. N."

"May 17.—'Have returned to this point. Reached 83 deg. 50 min. north latitude due north of here. Stopped by extremely rough ice intersected by water cracks. Water sky to north. Am now going east along the coast. Fine weather.'

"May 26.—'Have again returned to this place. Reached point on east coast about north latitude 83 deg. Open water all along the coast a few miles off. No land seen to north or east. Last seven days continuous fogs, wind, and snow. Is now snowing, with strong westerly wind. Temperature 20 deg. F. Ten musk oxen killed east of here. Expect to start for Conger to-morrow.'"

At Cape Washington, also, I placed a copy of Lockwood's record, from the cairn at Lockwood Island, with the following indorsement:

"This copy of the record left by Lieut. J. B. Lockwood and Sergt. (now Colonel) D. L. Brainard, U. S. Army, in the cairn on Lockwood Island, southwest of here, May 16, 1882, is to-day placed by me in this cairn on the farthest land seen by them, as a tribute to two brave men, one of whom gave his life for his Arctic work."

May 29.—For a few minutes on one of the marches the fog lifted, giving us a magnificent panorama of the north coast mountains. Very somber and savage they looked, towering white as marble with the newly fallen snow, under their low threatening canopy of lead-colored clouds. Two herds of musk oxen were passed—one of fifteen and one of eighteen—and two or three stragglers. Four of these were shot for dog food, and the skin of one, killed within less than a mile of the extreme northern point, has been brought back as a trophy for the club.

Once free of the fog off Mary Murray Island we made rapid progress, reaching Cape North in four marches from Cape Washington. Clear weather showed us the existence of open water a few miles off the shore, extending from Dome Cape to Cape Washington. At Black Cape there was a large open water reaching from the shore northward. Everywhere along the coast I was impressed by the startling evidences of the violence of the blizzard of a few days before. The polar pack had been driven resistlessly in against the iron coast, and at every projecting point had risen to the crest of the ridge of old ice, along the outer edge of the ice foot in a terrific cataract of huge blocks. In places these mountains of shattered ice were 100 feet or more in height. The old ice in the bays and fjords had had its outer edge loaded with a great ridge of ice fragments, and was itself cracked and crumpled into huge swells by the resistless pressure. All the young ice which had helped us on our outward passage had been crushed into countless fragments, and swallowed up in the general chaos.

Though hampered by fog, the passage from Cape North to Cape Bryant was made in twenty-five and a half marching hours. At 7 A. M. of the 6th of June, we camped on the end of the ice-foot, at the eastern end of Black Horn Cliffs. A point a few hundred feet up the bluffs commanding the region in front of the cliffs showed it to be filled by small pieces of old ice held in place against the shore by pressure of the outside pack. It promised at best the heaviest kind of work, with the certainty that it would run abroad at the first release of pressure.

The next day, when about one-third the way across, the ice did begin to open out, and it was only after a rapid and hazardous dash from cake to cake that we reached an old floe, which after several hours of heavy work allowed us to climb upon the ice-foot of the western end of the cliffs.

From here on rapid progress was made again, three more marches taking us to Conger, where we arrived at 1:30 A. M., June 10, though the open water between Repulse Harbor and Cape Brevoort, which had now expanded down Robeson Channel to a point below Cape Sumner, and the rotten ice under Cape Sumner hampered us seriously. In passing I took copies of the Beaumont English records from the cairn at Repulse Harbor, and brought them back for the archives of the club. They form one of the finest chapters of the most splendid courage, fortitude, and endurance, under dire stress of circumstances, that is to be found in the history of Arctic explorations.

(To be concluded.)

THE ENGINEER AS A BUSINESS MAN.

The following striking passages are culled from an address delivered by A. C. Humphreys to the students of the University of Wisconsin:

"About eighteen years ago I was called in to examine a process for which it was claimed that from two barrels of oil could be produced 200,000 feet of gas, high in candle power and high in calorific power. The promoters were able to produce, in verification of their claims, certificates from a number of gas engineers, and, I am sorry to say, from two professors of high reputation, members then of the faculty of a prominent engineering college. The certificate of one of these professors stated that the volume of gas produced under his observation confirmed the claim as to volume. The other professor's certificate stated that the gas produced had been found to be equal in candle-power and calorific power to the claims. I noticed, however, that these certificates showed that the work on volume and the work on intensity or quality had been performed on different days. I was reluctant to undertake an investigation because manifestly the claims were ridiculous. On account of several people strong in the financial world, friends of our company, being concerned I was finally persuaded to undertake the investigation. I went off with a number of my men, set up the apparatus and left it in charge of a man who is now my partner and who at that time had only recently graduated from Stevens Institute. In giving him his instructions I told him that when he signed his report it would be necessary for him to bear in mind that when he fixed his signature I should understand that every word in his report he was personally responsible for; that he had taken nobody's word for anything, even to the minutest detail. He made the remark that this would be liable to put him into some very embarrassing positions. I told him it was sure to do so. Being a very polished Southern gentleman, this was evidently very disagreeable to him. The work went on for six weeks. We were constantly hampered by objections to the measures we were taking for the final determination. I visited the works myself once a week and it was apparent finally that oil was being introduced to the apparatus surreptitiously and I told my men to find the hidden pipe which was so being used. Shortly after my return from this last visit I received a telegram from my assistant in charge saying: 'Have discovered the pipe. Can do nothing unless I seal the valve. This will indicate a lack of confidence. What shall I do?' I wired back: 'You have your instructions and know what will be expected if you sign the report.' I received another telegram in reply: 'Valve sealed.' The next morning I got another telegram: 'Works burned down, valve, seal, and all.' So we had finally forced them to face a disclosure of the fraud and they preferred to have an accident at the works."

What will probably be the first international convention for the regulation of electric power is now being negotiated between Switzerland and Germany. The agreement refers to the utilization of the Rhine at Laufenburg, and it is drawn in thirty-three articles, which are now being examined in the Chamber of Commerce of Schopfeim, in the light of explanations furnished by the promoters. The project contemplates the generation of electric force to the extent of 50,000 horse-power.

ON THE MODERN REFLECTING TELESCOPE, AND THE MAKING AND TESTING OF OPTICAL MIRRORS.*

By G. W. RITCHEY.

INTRODUCTION.

THE present paper describes the methods employed by the writer in the optical laboratory of the Yerkes Observatory in making and testing spherical, plane, paraboloidal, and (convex) hyperboloidal mirrors. On account of the very great importance of supporting mirrors properly in their cells when in use in the telescope, a chapter is devoted to the description of an efficient support system for large mirrors. Intimately related to this, and equally important, is the subject of the mounting—the mechanical parts—of a modern reflecting telescope; accordingly, the final chapter is devoted to a consideration of this subject.

I. DISKS OF GLASS FOR OPTICAL MIRRORS.

No greater mistake could be made than to assume that cheap and poorly annealed disks of glass, or those with large striæ or pouring marks, are good enough for mirrors of reflecting telescopes. While I am not prepared to say that optical glass of the finest quality must be used for mirrors in order to secure the best attainable results, it is evident that a very high degree of homogeneity and freedom from strain is necessary in order that the figure of mirrors shall not be injuriously affected by changes of temperature. If it were not necessary to consider the question of cost, I should advise the use of the finest optical (crown) glass always, in order to be as free as possible from risk; usually considerations of cost would, in the case of large mirrors, make it necessary to choose between such an optical disk of a given size and a somewhat larger one of the kind furnished by the St. Gobain Company, for example. The diagonal plane mirror of a Newtonian, and the convex mirror of a Cassegrain reflector, should always be made of the best optical glass, since the expense for these is comparatively slight.

The writer has used many disks made at the celebrated glass-works of St. Gobain, near Paris, of sizes from 8 inches in diameter and 1½ inches thick, to the great one shown in the plates accompanying this article, which is 5 feet in diameter and 8 inches thick, and weighs a ton. All of these disks are beautifully free from bubbles and large striæ, and are fairly well annealed, considering their great thickness. It is a most encouraging fact that the quality of the 5-foot disk is not inferior in any respect to that of disks of 8, 12, 20, 24, and 30 inches diameter which I have used. The makers of the 5-foot disk have recently expressed their readiness to undertake for us a 10-foot disk, one foot thick, which they think could now be made as perfect in all respects as the 5-foot disk. In ordering these disks it is always specified that great care be given to thorough stirring and thorough annealing. I have no doubt that in the case of very large and thick disks the makers could be prevailed upon to give even greater care to these points than is now given.

A very important point is in regard to the best thickness of optical mirrors. As a result of experience in making and using many mirrors of 24 and 30 inches diameter, in which the thickness of the several disks varies from one-twelfth to one-sixth of the diameter, I have no doubt that the thicker disks are always preferable, provided that they are as homogeneous and well annealed as the thinner ones. The thinner mirrors suffer much greater temporary change of curvature from the very slight heat generated during the process of polishing; and they are undoubtedly more liable to suffer temporary disturbance of figure from changes of temperature when in use in the telescope. In the cases of the large paraboloidal mirror of a reflecting telescope, and the large plane mirror of a cœlostat or heliostat, which should always be supported at the back to prevent flexure, the thickness should not be less than one-eighth or one-seventh of the diameter; in the writer's opinion the latter ratio leaves nothing to be desired. In the cases of the small diagonal plane mirror and the small convex mirror, which cannot easily be supported at the back, the thickness should be not less than one-sixth of the diameter.

All mirrors should be polished (not figured) and silvered on the back as well as on the face, in order that both sides shall be similarly affected by temperature changes when in use in the telescope; for the same reason the method of supporting the large mirror at the back, in its cell, should be such that the back is as fully exposed to the air as possible.

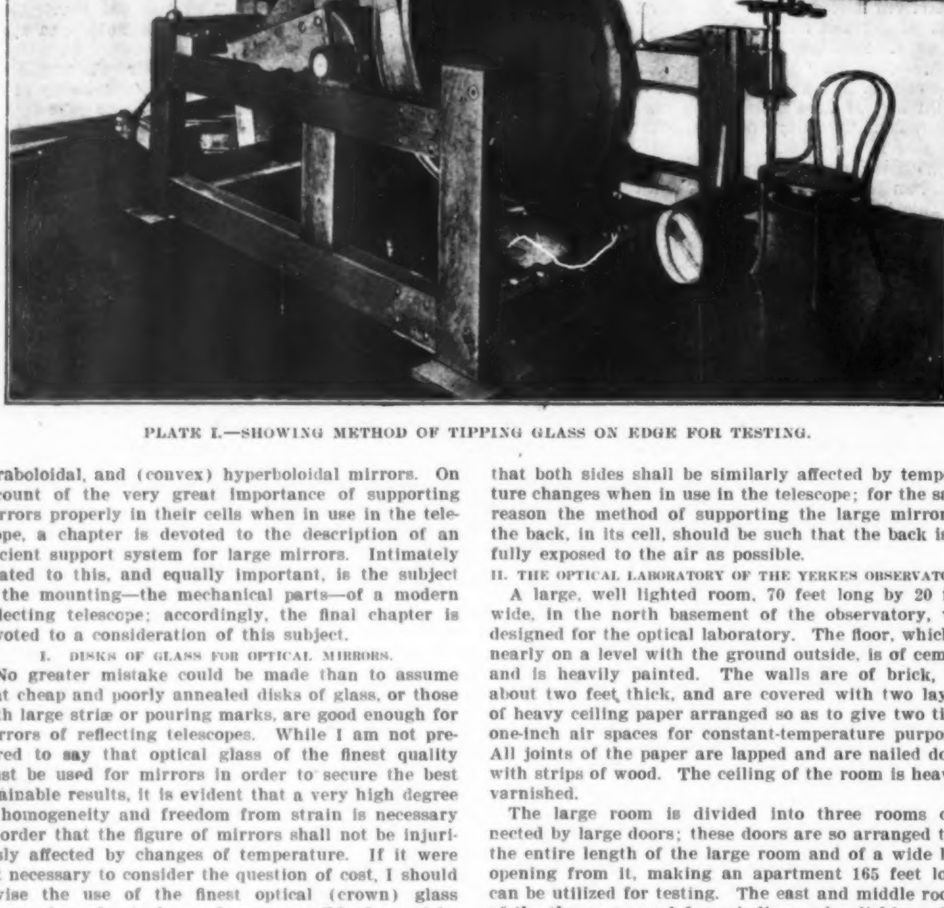


PLATE I.—SHOWING METHOD OF TIPPING GLASS ON EDGE FOR TESTING.

II. THE OPTICAL LABORATORY OF THE YERKES OBSERVATORY.

A large, well lighted room, 70 feet long by 20 feet wide, in the north basement of the observatory, was designed for the optical laboratory. The floor, which is nearly on a level with the ground outside, is of cement and is heavily painted. The walls are of brick, are about two feet thick, and are covered with two layers of heavy ceiling paper arranged so as to give two tight one-inch air spaces for constant-temperature purposes. All joints of the paper are lapped and are nailed down with strips of wood. The ceiling of the room is heavily varnished.

The large room is divided into three rooms connected by large doors; these doors are so arranged that the entire length of the large room and of a wide hall opening from it, making an apartment 165 feet long, can be utilized for testing. The east and middle rooms of the three are used for grinding and polishing. The large windows of these rooms are fitted with storm sash on the inside; these are built in permanently and are made air-tight by means of ceiling paper. The west room contains the motor which supplies power to the grinding and polishing machines in the inner rooms; power is transmitted by a long shaft which runs the entire length of the rooms; this shaft is built in air-tight (to prevent dust) beneath the long work-bench which runs along one side of the rooms.

With these arrangements temperature, moisture, and freedom from dust can be controlled in the grinding and polishing rooms with all necessary refinement. In other respects, however, three great improvements could be made in planning an ideal optical shop; two of these relate to the comfort and health of the optician. First, the rooms should be arranged so that direct sunlight could be admitted to them during all parts of the optical work in which this would not be injurious to the work itself. Second, provision should be made for supplying to the rooms an abundance of fresh air, of a definite temperature, and washed free from dust. Third, for constant-temperature purposes, walls and partitions covered with a heavy layer of asbestos plaster (commercially termed asbestic) would be preferable, on account of the superiority of the insulating and fire-proofing qualities of this material, to those of ceiling paper with air-spaces.

III. GRINDING AND POLISHING MACHINES.

The grinding and polishing machines used by the writer are somewhat similar in principle to Dr. Draper's machine, shown in Fig. 25 of his book, but are more elaborate. I shall describe here the machine used in making the 5-foot mirror, both because it embodies most of the essential features of a grinding and polishing machine, and also because it is the only one of my machines of which I have a series of photographs for illustration. A good idea of this machine may be gained from the views of it shown in Plates I, II, III, and IV.

The massive turntable upon which the glass rests consists of a vertical shaft or axis five inches in diameter, carrying at its upper end a very heavy triangular casting, upon which, in turn, is supported the circular plate upon which the glass lies. This plate is of cast-iron, weighs 1 800 pounds, is 61 inches in diameter, is heavily ribbed on its lower surface, and is connected to its supporting triangle by means of three large leveling screws. The surface of the large plate was turned and then ground approximately flat; two thicknesses of Brussels carpet are laid upon this, and the glass, with its lower surface previously ground flat, rests upon the innumerable springs formed by the looped threads of the carpet. No better support for a glass during grinding and polishing could be desired.

Three adjustable iron arcs at the edge of the glass serve for centering the latter upon the turntable, and prevent it from slipping laterally.

The entire turntable, with the heavy frame of wood and metal which supports it, can be turned through 90 deg. about a horizontal axis, thus enabling the optician to turn the glass quickly from the horizontal position which it occupies during grinding and polishing, to a vertical position for testing. This is shown in Plate I.

The turntable is slowly rotated on its vertical axis by means of the large pulley below (Plate II.). This rotation is effected by means of belting from the main vertical crank-shaft on the east end of the machine; this shaft is well shown at the left in Plate III. At the upper end of this shaft is the large crank, with adjustable throw or stroke, which moves the large and strong main arm to which the grinding and polishing tools are connected, and by means of which they are moved about upon the glass. This I shall always refer to as the main arm. It is a square tube of oak wood, and is strong enough to carry the counterpoising lever shown in Plate III., and the weight of any of the grinding tools, when fully or partially counterpoised. This main arm also carries the system of pulleys and belts by which the slow rotation of the grinding and polishing tools is rigorously controlled; these, and the manner in which this rotation is effected, are well shown in Plate III.

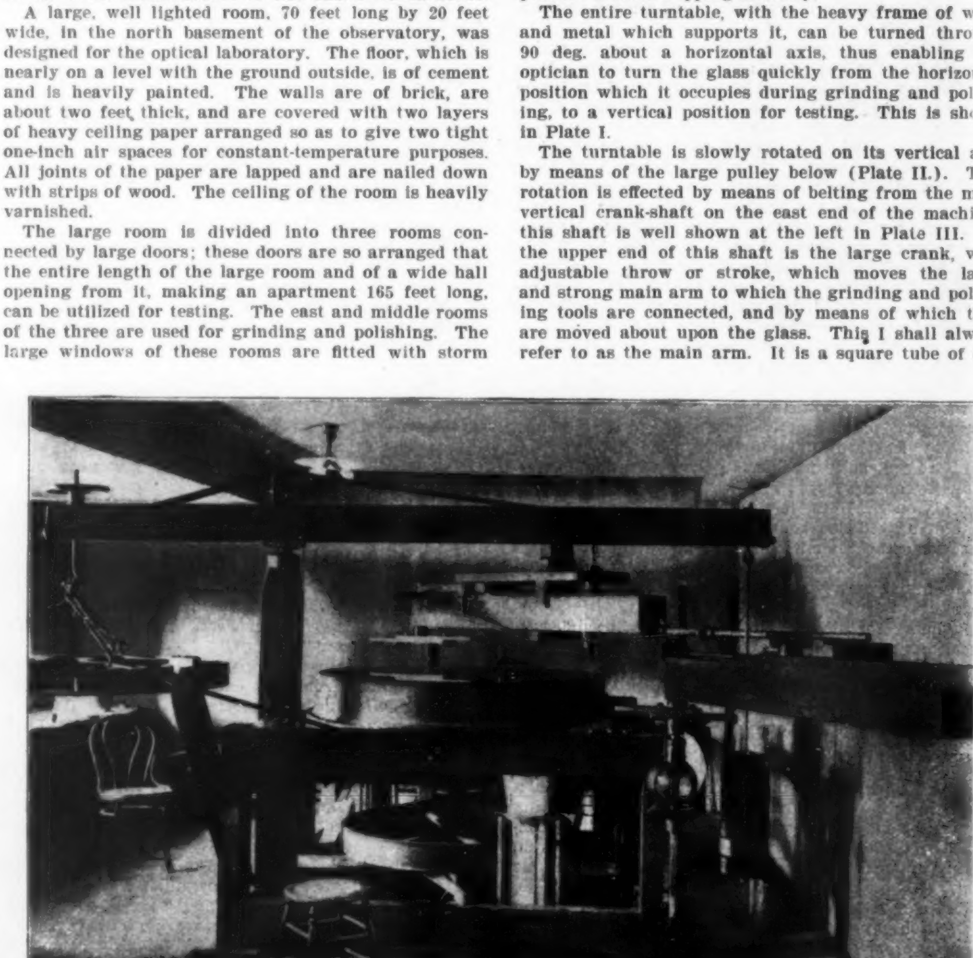


PLATE II.—SHOWING LEVER FOR HANDLING HEAVY GRINDING AND POLISHING TOOLS.

FIVE-FOOT MIRROR AND GRINDING MACHINE.

* Reprinted from vol. xxxiv, Smithsonian Contributions to Knowledge.

The west end of the main arm consists of a strong steel shaft which slides in a massive bronze swivel-bearing which corresponds to the "elliptical hole in the oak block p" of Dr. Draper's machine (see his Fig. 25). But this bearing is not stationary as in Draper's machine; it is not only mounted on a long slide (which I shall refer to throughout this article as the transverse slide), so that it can be slowly moved for several feet across the west end of the machine by means of a long screw, but this bearing and slide are carried upon a secondary strong arm, which is moved by a secondary crank at the southwest corner of the machine. Unfortunately there is no photograph which shows this part of the machine as it appears when in use; Plates I. and II. show the secondary crank well, but the secondary arm is shown swung around with one end resting on a bracket on the wall, in order to have it out of the way.

The arrangement of the west end of the machine is the result of experience with several machines, and is found extremely serviceable and convenient. The long transverse slide on the secondary arm allows the grinding and polishing tools to be placed so as to act on any desired zone of the glass, from the center to the edge; and this setting can be changed as desired while the machine is running. The secondary crank, which turns at the same speed as the large one which drives the main arm, enables the optician to change as desired the width of the (approximately) elliptical stroke or path of the tool with reference to the length of this stroke; this change is especially desirable when figuring the glass; it is, of course, impossible when only one driving-crank is used.

I regard the transverse slide, or something equivalent to it, as absolutely necessary to the success of a grinding and polishing machine; it will be noticed that its purpose corresponds, in some measure, to that of the long slot in the main arm of Draper's machine. I have used both arrangements and have found the transverse slide to be far more effective and convenient in use; its use will be described in the chapters on grinding and polishing.

The secondary crank, while very desirable and convenient, for the reason given above, is not indispensable; I have used several smaller machines which have given good results without it.

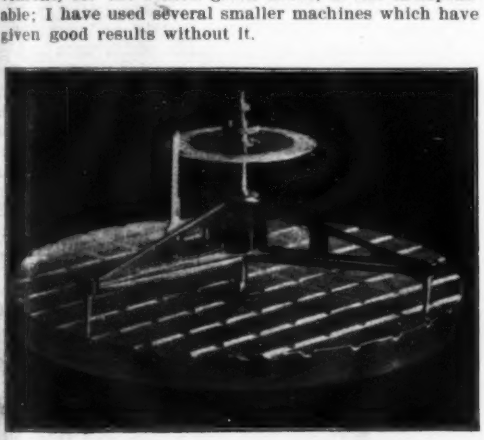


PLATE IV.—LARGE SPHEROMETER ON TWELVE-INCH GLASS GRINDING TOOL.

The manner in which the grinding and polishing tools are connected to the main arm is shown in Plate III. A vertical shaft, 1¾ inches in diameter and 24 inches long, both rotates and slides (vertically) freely in bronze bearings attached to the main arm. The grinding and polishing tools are connected to the lower end of this shaft through the medium of a large universal coupling—a gimbal or Hooke's joint—with two pairs of horizontal pivots at right angles to each other; this allows the tools to rock freely in all directions in order to follow the curvature of the glass. The tools are lifted, for counterpoising them, by the lever above (see Plate III.), through the medium of the vertical shaft and the universal coupling. In the case of very massive grinding tools of moderate size, like that shown in this illustration, the universal coupling is connected directly to the back of the tool; but in the case of all large tools which are to be used for fine work this connection is made through the medium of a system of bars and triangles, so that the tools are counterpoised without the slightest danger of changing their shape. A small coupling with ball bearings at the upper end of the vertical shaft allows the latter to rotate freely with reference to the link which connects it to the counterpoise lever.

To recapitulate briefly: This method of connecting the grinding and polishing tools allows them to be controlled in all of the following ways simultaneously: (1) the stroke of the tool is given by the motion of the main arm; (2) the slow rotation of the tool is rigorously controlled by the belting above; (3) the tool is allowed to rock or tip freely by means of the universal coupling, in order that it may follow the curvature of the glass; (4) the tool rises and falls freely by means of the sliding of the 1¾-inch vertical shaft in its bearings, in order that it may follow the curvature of the glass; (5) the tool is counterpoised by means of the lever on the main arm, through the medium of the same vertical shaft and universal coupling.

In Plate II. is shown the large lever by which the 5-foot glass, which weighs a ton, is lifted on and off the machine, and by means of which, also, the large grinding tools are handled. One of the full-size grinding tools, weighing 1,000 pounds, is shown suspended by the lever. The arrangements are so convenient that the optician alone can do all parts of the work.

IV. GRINDING TOOLS.

While grinding tools of glass were used in much of my earlier work, and are still used for small work, I now use cast-iron grinding tools for all large work. These are cast very heavy, with ribs on the back; the ribs are made heavy, but not deep (or high). For large work iron tools are cheaper than glass ones; they are more easily prepared; they are more easily and safely counterpoised, which is always necessary in the fine-grinding of large work; and they produce on the glass a fine-ground surface fully as smooth and perfect as can be obtained with glass tools.

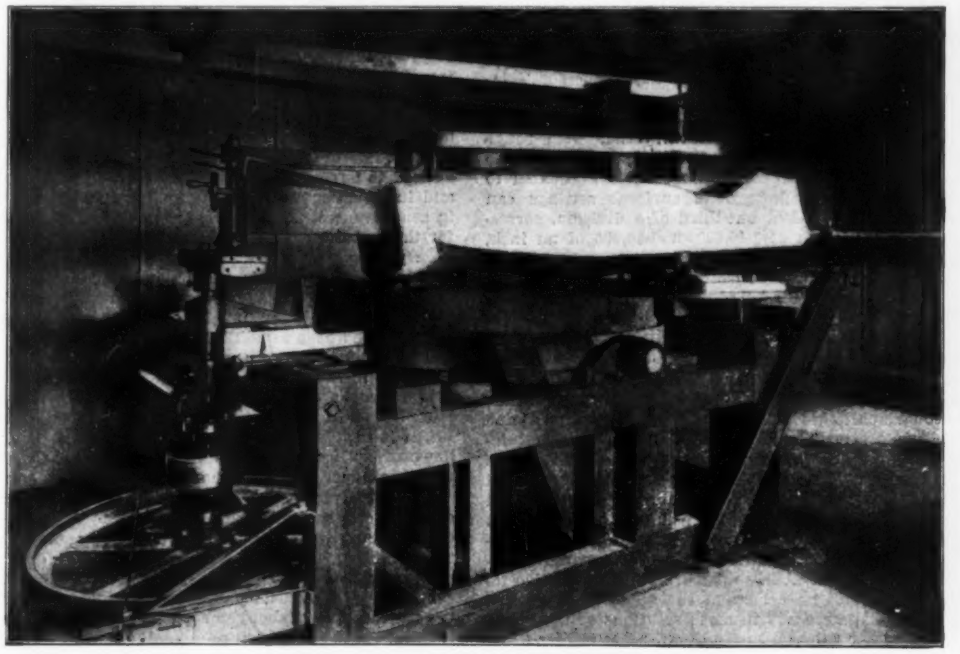


PLATE III.—SHOWING HALF-SIZE GRINDING TOOL SUSPENDED ON MAIN ARM.

An important question is in regard to the size of grinding tools—whether they should be of the same diameter as the mirror. For mirrors up to 24 or 30 inches in diameter full-size tools are generally used. For concave mirrors larger than 30 inches in diameter I use grinding tools whose diameter is slightly more than half that of the glass, i. e., a 16-inch tool for a 30-inch glass; a 32-inch tool for a 60-inch glass. These I shall refer to as half-size tools. Full-size tools are, of course, much more expensive and difficult to make; they are many times heavier than half-size tools of equal stiffness; and they require a much stronger grinding machine to counterpoise them properly; grinding can be done with them, however, more quickly than with the smaller tools. Half-size tools are economical and are quickly prepared; they are easily counterpoised; and a much greater variety of stroke can be used with them, so that with a well-designed grinding machine I have found it easier to produce fine-ground surfaces, entirely free from zones, with half-size than with full-size tools. If temperature conditions and uniform rotation of the glass are carefully attended to, the surface of revolution produced by the smaller tools is fully as perfect as that given by the larger ones; I always take the precaution, however, to work a full-size approximately flat tool on the glass before beginning to excavate the concave, so as to start out with a surface of revolution.

Grinding tools for concave and convex mirrors are always made in pairs, one concave, the other convex. Grinding tools for plane mirrors are made in triplicate. These iron tools, when being cast, are "poured" face down, so that the faces will be clean. I shall describe the preparation of a pair of iron tools for a concave mirror, leaving the description of tools for plane mirrors until the making of plane mirrors is discussed. The convex and concave tools are turned in a lathe to the proper curvature as shown by templets. The convex tool, which is, of course, to be used on the concave glass, is now placed on a planing machine, and has a series of grooves cut across the convex surface. These grooves are usually ¼ inch wide, and run in two directions at right angles to each other; these divide the surface into squares, which are usually made about one inch on a side. These grooves serve to distribute the grinding material uniformly, and entirely obviate the tendency of the tools to cling to the glass in fine-grinding. No grooves are cut in the concave tool. A number of holes are now bored through both tools, in such positions that wooden cups or funnels can be inserted into the holes from the back or ribbed side of the tool, without interfering with the ribs; these cups serve for the introduction of the grinding material during the process of grinding; they should be thoroughly varnished.

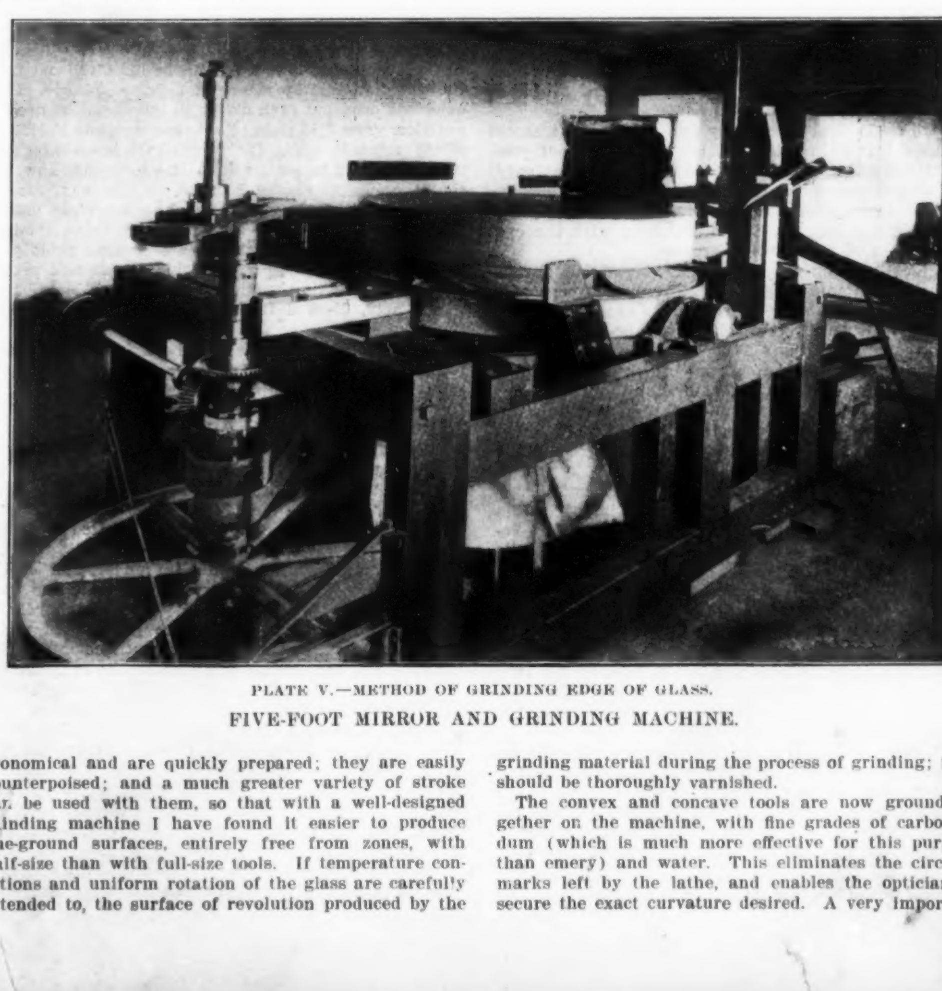


PLATE V.—METHOD OF GRINDING EDGE OF GLASS.

FIVE-FOOT MIRROR AND GRINDING MACHINE.

The convex and concave tools are now ground together on the machine, with fine grades of carborundum (which is much more effective for this purpose than emery) and water. This eliminates the circular marks left by the lathe, and enables the optician to secure the exact curvature desired. A very important

point is that by grinding with the concave tool on top, the radii of curvature of both tools can be gradually shortened; when the convex tool is used on top the curvature of both is gradually flattened. By this means, and the use of very fine grades of carborundum, a most perfect control of the curvature of the tools may be had.

The curvature of the tools and of the glass is measured by means of a large spherometer; this is shown in Plate IV., resting upon a 12-inch glass grinding tool. The spherometer is of the usual three-leg form; the legs terminate in knife-edges, the lines of which are parts of the circumference of a 10-inch circle. The central screw is very carefully made; it was ground in its long nut (which was made adjustable for tightness) with very fine grades of emery such as are used in optical work; screw and nut were then smoothed and polished by working them together with rouge and oil. The screw is of ½ millimeter pitch, and the head, which is 4 inches in diameter, is graduated to 400 divisions. On fine-ground surfaces settings can be made to one-half or one-third of a division, corresponding to a depth of 1-40,000 or 1-60,000 of an inch, approximately.

(To be continued.)

NEW PROCESS OF COLOR-PHOTOGRAPHY BASED ON THE USE OF ORGANIC DYES.*

WHILE the leuco-bases of some classes of organic compounds, e. g., the safranins, are so readily oxidized that they cannot be isolated as such at all, others like leuco-malachite green can readily be prepared pure, and are comparatively stable in air. The only exact investigations, however, which have been made on the sensitiveness to light of leuco-bases, are those carried out by Gros in Ostwald's laboratory. He examined particularly the leuco-compound of fluorescein and its substitution products. He observed that the leuco-compounds (which, by the way, were prepared somewhat crudely) are nearly all more or less sensitive toward light, and he measured the quantity of oxygen which was absorbed by aqueous solutions of the leuco-bases or their salts.

Except Gros, no one seems to have investigated these points at all exhaustively, or to have thought of using the leuco-bases for the production of photographic images.

Before entering upon my subject proper, I must first say a few words on a point of pure photographic technique. The principle on which the "three-color process" of photography is based, I may presumably take to be well known to you: Three negatives are prepared of the object photographed, the first showing on the print only the blue parts, the second only the red parts, and the third only the yellow parts of the object.

The preparation of such negatives is comparatively simple, and the chief reason why the three-color photographic process, which in the arts has found important application, still fails to come into general use in photographic practice, lies in want of a suitable copying process.

I will not enter into an enumeration of the various copying processes, but I shall only briefly mention that all methods hitherto employed are based upon the sensitiveness of gelatine treated with bichromate; the print may be either produced directly upon a pigment paper previously colored, or the gelatine images obtained, colorless at first, are subsequently dyed with organic dye-stuffs. The three monochrome component images, however prepared, are finally united into one, which then reproduces all the different shades of the original.

There is no doubt that very fine three-color images can be obtained in this way, but the process of preparing the pictures is so extremely difficult that only a chosen few succeed in producing pleasing effects. And not least among the disadvantages of this old method is the impossibility of watching with the eye the progress of the printing process.

An ideal copying process would evidently be one in which there is no dyeing, or printing upon dyed paper, a process in which only colorless films are used, which on exposure turn directly yellow, red, or blue, according to their preparation.

In search after such a copying process, we, together with the photo-chemical laboratory of the Farbwerke vormals Meister, Lucius, und Brüning at Höchst-on-the-Main, carried on exhaustive work with a great variety of leuco-bases, but we were soon forced to the conclusion that the leuco-bases, exposed by themselves to the light, are incapable of yielding sufficiently strong and brilliant images. We then imbedded the leuco-bases in a layer of a cetyl hydrocellulose or gelatine, but our hope to produce stronger images in this way was not fulfilled.

Not until collodion was chosen as basis for the picture was any marked progress made in the sensitiveness. But with this substance immediately a great advance was made. Leuco-bases which, when exposed by themselves to the light for hours, gave only a very feeble coloration, were pretty strongly oxidized in the presence of collodion even after a much shorter exposure, and gave satisfactory images.

We soon realized that the collodion cannot here act simply as support for the picture. And, indeed, it soon became clear that the leuco-bases were oxidized in the light at the expense of the nitric acid group of the nitro-cellulose. We next examined a large number of other bodies, and all esters of nitric acid, especially those of polyhydric alcohols, react in the same way as nitrocellulose. The organic nitrites, on the other hand, and the isomeric nitro bodies of the aliphatic and aromatic series, are inactive, as are also inorganic nitrates. The nitrosamines display similar, but less marked action as nitric acid esters.

It is interesting to note that the sensitiveness to light of the mixture of nitrocellulose and leuco-base may be greatly diminished by the addition of urea or antipyrin. This fact seems to indicate that the leuco-bases are actually oxidized by oxides of nitrogen split off from the collodion.

The addition of turpentine or anise-oil, which are regarded as oxygen carriers, has little or no accelerating action upon the production of these photographic images. But upon one occasion, when we added various organic bases to the collodion solution of the leuco-bodies for the purpose of preventing a slight oxidation which some of them undergo in contact with air, we noticed to our surprise, that films containing quinoline and its homologues showed a further marked increase in sensitiveness. I am unable to offer any explanation for this peculiar effect; we have here evidently a catalytic process.

Now nitrocellulose is not by any means the most efficient of the above-mentioned compounds, only it is peculiarly adapted for the production of pictures, since it furnishes at the same time the film for their support. Far more sensitive still are mixtures of the leuco-bases with the nitrates of glycerine, glucose, and mannitol.

If a piece of filter-paper is wetted with a solution of leuco-malachite green, for instance, or of leuco-flavanilin, it is hardly colored on brief exposure to light; if, however, a little nitromannitol is added to the solution, the paper quickly assumes an intense coloration.

The sensitiveness of mixtures of leuco-base and nitrocellulose can be increased enormously by the addition of nitromannitol. You see here two pictures, of which the one is much stronger than the other. The exposure was twenty seconds in sunlight in each case. The sensitive film consisted of nitro-cellulose, o-amidotetrethyldiamidotriphenyl-methane, and quinoline; to the film for the first picture a small quantity of mannitol was also added.

I wish to emphasize the fact that it is quite impossible to produce photographic images giving any approach even to satisfaction by means of leuco-bases alone, or of leuco-bases imbedded in different films. The copies always turn out flat and feeble, the oxidation of the leuco-bases in light by atmospheric oxygen seems soon to reach a maximum, long before the whole of the leuco-base is oxidized.

Some bodies also which are not leuco-bases in the ordinary sense of the word are oxidized to dye-stuffs in light and in the presence of the organic nitrates mentioned repeatedly above. Such a substance, for instance, is paramidodiphenylamine. This compound is well known in the textile-printing industry under the name of "oxidation black." Mixed with collodion or similar bodies and applied to paper, it rapidly yields intensely colored images on exposure to light.

Blue images can, for instance, be produced by means of orthochlortetrethyldiamidotriphenyl-methane, green images by means of leuco-malachite green, meta-nitro- or metamidotetrethyldiamidotriphenyl-methane, red images by means of para-leucaniline or leuco-rhodamines, violet images by means of hexamethyl-paraleucaniline, yellow images with leuco-fluorescein and leuco-flavanilin.

The fixing of the images at first gave great difficulty. Some leuco-bases, it is true, can be dissolved out from the collodion film by means of benzine, toluene, ether, or chloroform, but such fixing media cannot be used in practice. The first fixing fluid that suggests itself is a dilute mineral acid, for nearly all leuco-bases are readily soluble in such acids. It was found, however, that the images cannot be fixed in this way, for the leuco-bases, like the dye-stuffs, show a certain affinity for the nitro-cellulose, and are sometimes retained tenaciously. Fixation with dilute organic acids gave more success, and finally monochlor-acetic acid proved to be the best fixing medium for nearly all leuco-bases. Acetic acid, di- and trichlor-acetic acid do not serve the purpose.

Gros already investigated the behavior of leuco-bases toward light of different colors, and he laid down the "rough" rule (as he himself calls it) that most leuco-bases are colored most intensely on exposure to light of the complementary color. Gros obtained the feeblest action with all leuco-bases under red glass, the strongest action under "rose-colored" glass. We exposed the different sensitive films under light-filters, such as are used for the additive process of three-color photography; the results obtained showed that the strips exposed give a maximum under the filter of the complementary color, a minimum under that of the same color. Thus blue, green and violet are very strongly colored under red and yellow, but hardly at all under blue. Red is very strongly colored under the green or yellow filter, is not much colored under the blue, and not affected at all under the red. Lastly, yellow is strongly colored under blue, but remains untouched under yellow or red. For comparison, a strip of celloidin paper is here pasted on the table along with the others. It, of course, shows the deepest blackening under the blue.

The strong action of the so-called "inactinic" red on the blue and green sensitive films is very interesting, and is probably to be ascribed to the optic sensitizing action exerted by the dye-stuff produced.

It has been pointed out by Ostwald that the action of light on photographic preparations is not peculiar, that on the contrary light only accelerates reactions which would also take place of their own accord after some time in the dark. Thus it is well known that photographic plates and copying paper are decomposed even in the dark on prolonged keeping; this effect is particularly rapid in the case of the gelatin sensitized with dichromate. Now it is very much the same with our new sensitive films. The action which the light produces in a few seconds, takes place in the dark also after a lapse of hours, days, or weeks, the most sensitive being also the least stable in the dark, so that they must always be prepared shortly before use. I will, however, remark that even on very prolonged keeping the films are never colored as deeply as by a short exposure to light.

The application of these observations to three-color photography now is as follows:

A sheet of paper is covered with the collodion-blue, and exposed under the corresponding component negative. If the image appears in proper force, it is fixed in a solution of chloracetic acid of about 10 per cent strength, washed with water, covered with a thin hardened gelatine film, and dried. This gelatine film serves to protect the first collodion film from becoming dissolved when the second is applied. Over the dry blue image the collodion-red is then poured, and the corresponding component negative is then applied in such manner that the outlines of the negative fit in exactly with those of the blue image. The sheet is then again exposed to the light, is fixed, washed, and the yellow image is then prepared in a precisely similar manner. Owing to the perfectly transparent character of the extremely thin films, and the brilliancy of the colors employed, the copies have a very uniform appearance, and especially the mixed colors appear to great advantage.

The quantity of leuco-bases actually used is very small, owing to the enormous coloring power of the triphenylmethane dye-stuffs; a picture of 200 square centimeters surface contains only about 2 milligrammes of dye-stuff.

The pictures are not, of course, absolutely permanent in light, although comparatively fast dyes may be used for the preparation of the component images. The least light-fast is the blue, which nevertheless exceeds in permanence the well-known ferrotype blue-prints.

When we consider the difficulties which were hitherto opposed to the copying of three-color negatives, the new direct-copying process of the "Farbwerke" at Höchst must be regarded as a great step forward. Colored transparencies were comparatively easy to prepare, as is well known, but the three-color photographic process could not become popular, so long as it remained impossible to produce pictures on paper in some simple way. This, we imagine, is the want which our copying process supplies even for the unpractical amateur. We must hope that it will help to bring new life into the interest taken in photography, which has of late been somewhat on the wane.—Translated from Zeitschrift für angewandte Chemie, 1904 (17), No. 44, page 1,633.

* Lecture delivered in the section of chemistry at the seventy-sixth meeting of German Scientists and Physicians by E. König.

CONTEMPORARY ELECTRICAL SCIENCE.*

IONIZATION RECORDER.—C. Nordmann has invented an instrument which he calls the "ionograph," and which is intended to give a continuous reading and automatic record of the state of ionization of the atmosphere and of gases. The gas to be studied is introduced between the armatures of a condenser. One armature is raised to a potential sufficient to produce the saturation current. The other armature is joined to an electrometer on the one hand, and to the earth through the intermediary of a very high resistance on the other. Under the influence of the field between the armatures, the second armature collects a certain quantity of electricity per second, such quantity being proportional to the number of ions produced per second between the armatures. If C is the capacity and E the potential of the second armature and its electrometer connections, its charge, CE, at the end of a time t equals Qt, less the quantity of electricity lost to the earth through the high resistance. By a suitable choice of the dimensions of the apparatus the readings for E may be made proportional to the values of the product QR, where Q is the quantity and R the high resistance. The best value of the high resistance is about 10 megohms. The registration of the actual ionization is then completed in about half a second.—C. Nordmann, Comptes Rendus, June 6, 1904.

RADIUM EMANATION.—An important communication on the properties and transformation of the radium emanation is made by Sir William Ramsay. In collaboration with Soddy, he has succeeded in determining the amount of emanation given out by radium bromide in a given time, and in determining the position of its brightest spectrum lines. They dissolved 70 mg of radium bromide in distilled water, and found that the water was gradually decomposed, giving rise to an explosive mixture of oxygen and hydrogen, with the latter predominating. This explosive mixture contained a small quantity of emanation. By detonating it and then introducing the tube into a liquid air refrigerator, they succeeded in condensing the emanation. Then they pumped away the hydrogen and obtained a small quantity of the pure emanation, which, after regaining the normal temperature and pressure, occupied a volume of one-fiftieth of a cubic millimeter. On gradually reducing the pressure, they found that the gas expanded, very nearly according to Boyle's law. The emanation, therefore, behaves like an ordi-

* Compiled by E. E. Fournier d'Albe in the Electrician.

nary gas. It emits sufficient light to read the time on a watch by. On observing the light with a spectroscope, the author found 18 lines, the strongest of which occurred at 5,595, 5,393 and 4,985. There were two fairly strong lines at 5,805 and 5,725 respectively, and another at 4,966, which, however, disappeared after a time. On keeping the emanation for a month, the luminosity gradually disappeared. On reducing the pressure and heating slightly, a gas having four times the volume was obtained, which showed the spectrum of helium. The emanation resembles the gases of the argon family, and its atomic weight is probably double its density. The latter is about 80, so that an atomic weight of about 160 would be indicated. That of radium being 225, it follows that one atom of radium cannot well give rise to more than one atom of emanation. Now, every gramme of radium gives 3×10^{-6} cubic millimeter of emanation per second. Hence the amount of radium transformed into emanation in one year is about one-thousandth part of its weight. This would mean that the life of radium is about 1,000 years. The heat emitted by the emanation is three or four million times the amount emitted by an equal volume of an explosive mixture of hydrogen and oxygen during explosion. In consideration of the fact that the emanation is a gas of independent, though destructible, properties, the author proposes to call it "exradio."—Sir William Ramsay, Comptes Rendus, June 6, 1904.

PROPORTION OF MEN TO WOMEN IN THE UNITED STATES.

A STUDY in the proportion of sexes in the United States has been published by the Bureau of the Census. The discussion and analysis were written by Prof. W. F. Willcox, of Cornell University; the tables themselves, derived from the main population reports of the Twelfth Census, were prepared under Prof. Willcox's supervision.

Some of the conclusions reached are of much scientific and practical importance, and may thus be summarized:

The whole population of continental United States was first counted with distinction of sex in 1820. During the seventy years from 1830 to 1900 the absolute excess of males was greater at each census than at any preceding census with one exception, that of 1870, when the excess of males was less than in 1850 and 1860. This reduction of the excess of males between 1860 and 1870 by about 300,000 was doubtless due to the deaths in the civil war and the diminished immigration during the decade. The greatest relative excess of males was in 1890, when in each 10,000 people there were 242 more males than females. By 1900 this excess had decreased to 216 in 10,000, less than the relative excess in 1890 and 1860, but greater than that at each other census. In continental United States there are 1,638,321 more males than females, or about 2 in each 100 people. Probably in the population of the world as a whole, and certainly in that half of it which has been counted with distinction of sex, there are several millions more males than females. In continental United States, however, the relative excess of males is greater than the average for all countries. Europe has an excess of females; every other continent, so far as known, has an excess of males.

The divisions of continental United States with the smallest proportion of males are the District of Columbia (47.4 per cent), Massachusetts (48.7 per cent), and Rhode Island (49.1 per cent); those with the largest are Wyoming (62.9 per cent), and Montana (61.6 per cent). As a rule sparsely settled regions have an excess of males and densely settled regions an excess of females.

Between 1890 and 1900 the divergence among the several States in this respect decreased and the proportion of males and of females in different sections became more nearly equal. In 1880 about one-fourth and in 1900 less than one-sixth of the American counties had an excess of females.

American cities as a rule have more females than males. In the 1,861 cities, each having in 1900 at least 2,500 inhabitants, there were 201,959 more females than males, and this notwithstanding the many western cities which contained more males than females and the enormous number of foreign born in the country, five-ninths of them male and a large proportion of them living in the cities. This tendency of American cities to develop a population having a majority of females had increased since 1890 when, in the 1,490 cities, each having at least 2,500 inhabitants, there were 6,929 more males than females.

While the excess of 6,929 males in American cities in 1890 became an excess of 210,959 females in American cities in 1900, the excess of 1,519,559 males in country districts in 1890 became an excess of 1,840,280 males in 1900.

Or, expressing the facts in ratios, of each 1,000 inhabitants of such cities in 1890, 500 were males, and in 1900, 497 were males; of each 1,000 inhabitants living outside these cities in 1890, 519 were males, and in 1900, 520 were males. The difference thus in the number of males or of females between an average thousand of city and of country population in 1890 was 19, and in 1900, 23.

This conclusion is not materially modified when a more accurate method is employed and a comparison made between the figures in 1890 and 1900 for the same list of cities, namely, all which had at least 2,500 inhabitants at each date.

A marked and increasing dissociation of the sexes between city and country like that in the United States has been noted also in the leading countries of western Europe.

On the other hand, there is a large excess of males in the principal cities of Russia and India, and in Hongkong and Manila.

This excess of females in the cities of western Europe and eastern United States is probably due mainly to the greater opportunity for women to find employment in those cities and to their migration cityward in consequence.

But even among children under 5 years of age, a slight difference appears between cities having at least 25,000 inhabitants and the rest of the country. In such cities there are 503 males to each 1,000 children; outside of them there are 506 males to each 1,000 children.

These figures support but do not prove the theory that the proportion of male children at birth is slightly less in cities than in country districts.

In all races and in all parts of the country there has been a decided increase since 1890 in the proportion of females among persons attending school. This increase is due mainly to the increase in the proportion of young women among persons at least 15 years of age attending school, the increase at this age period being nearly five times as great as at any other and more than three times as great as the average increase for all ages.

In 1890, among each 1,000 persons at least 15 years of age attending school, 528 were male; in 1900 only 490 were male.

No important change took place in the large cities. The change for the whole country was due to a rapid decrease outside of the cities in the proportion of young men among the persons at least 15 years of age attending school, the figures for the country districts approaching rapidly the proportion found in cities in 1900 and 1890.

When the school attendants of a specified class are compared with the total population of the same age and class, a noticeable contrast between the negro and the foreign born white population appears, the per cent of female negroes attending school at each age being larger than that of male negroes, and the per cent of female foreign born whites attending school at each age smaller than that of male foreign born whites.

Even for the age period 10 to 14 there has been, during the last decade, a slight decrease in the proportion of males attending school to male population, somewhat more than counterbalanced by an increase in the proportion of females attending school to female population.

The death rate of males in the registration area of the United States in 1900 was 19.0 per 1,000, and that of females 16.6 per 1,000, the former having a death rate higher by above one-seventh than the latter. In the 346 registration cities the death rate of males was 20.0 and that of females 17.2 per 1,000, the male rate exceeding the female by one-sixth. In the rest of the registration area the male death rate was 15.8 and that of females 15.0 per 1,000, the male rate exceeding the female by one-nineteenth.

The difference in the death rate of the sexes is apparently least between the ages of 5 to 14 and greatest at the youngest and oldest ages.

Life tables for Massachusetts, England, Prussia, and Norway confirm these conclusions and make them precise. They indicate that male children under 3 years of age have uniformly a higher death rate than female children.

There is a period between 5 and 21 years of age in which the death rate of females is slightly higher than that of males. According to the Massachusetts life table this period covers seventeen years, 5 to 21; according to the Norwegian life table, eleven years, 5 to 15; according to the Prussian life table, nine years, 8 to 16; and according to the English life table, eight years, 14 to 21.

According to all the life tables the death rate of women between 20 and 30 years of age, at which age probably four-fifths of the childbirths occur, was less than that of males.

AMERICAN AGE STATISTICS.

THE Bureau of the Census has just published, in the form of a bulletin, an interesting study and analysis of age statistics.

This bulletin was prepared under the supervision of Prof. Walter F. Willcox, of Cornell University, special agent of the Bureau of the Census, by Allyn A. Young, assistant professor of finance in Dartmouth College.

For the purpose of a scientific study of the population the classification by age is of great importance. Not only does this classification afford information concerning the generation which is at present doing the world's work, but it also makes it possible to form some conclusions about the generation next to enter on its estate. It is scarcely correct, however, to speak of "generations" in the sense in which the word is ordinarily used, because the population is being constantly recruited by births and depleted by deaths.

The population of a country has been compared with an endless rope made up of a vast number of individual threads. If the rope be cut at any given point, the threads thus exposed to view will vary from those so short that they can scarcely be measured to those of a maximum length. This is the view presented by the census age tables—a view which emphasizes the ever-changing character of the population.

The classification of a population by age makes it possible to measure its economic and military strength. A population containing a large proportion of aged persons and children may be less efficient than a smaller population in which a larger proportion are of productive age. Moreover, the proportion of young children in the population is at least as valuable an index of social conditions as is the birth rate, and is of special utility in the United States, where accurate records of the births are kept in few localities. The chief usefulness of age statistics, however, is found in the increased value which they give to the results of other census inquiries. The combination of the age and sex classifications reveals the number of voters and the number of potential fighting men. It is impossible to compare different classes of the population accurately with reference to such facts as crime, pauperism, illiteracy, number engaged in productive occupations, mortality rates, etc., without taking into account the differences in their age constitution; for example, the mere fact that death rates are higher in cities than in rural districts is without special significance until the differences in the age constitutions of the two regions are taken into account.

The ages of the population were ascertained more accurately at the census of 1900 than at any previous census of the United States. This improvement was largely due to the addition of an inquiry as to date of birth to the former direct question as to year of age.

The analysis of the census returns affords convincing evidence of the tendency to understate ages. This tendency manifests itself in the unduly large proportion of the population reporting their age as 25, 30, 35, 40, etc. A skillful analysis of the returns shows that except among persons of advanced years, this concentration on multiples of five represents in the majority of cases an understatement of age. The tendency to report ages as less than the truth is strongest in the negro population, stronger in the foreign born white than in the native white population, and is stronger with females than with males.

There is evidence of an overstatement of the ages of young children, which is explained as due to the tendency to denote a child's age by the year of life, rather than by the number of completed years. This leads to a large apparent deficiency of children in the first few years of life. The apparent deficiency is more marked in the case of children in the second year of life than of those in their first year—a result due to the fact that ages of children less than a year old are reported by months.

The age returns of the more illiterate classes of the population are less accurate than those of the more intelligent classes. Moreover, the distribution of errors in the age returns is such as to suggest that the census information obtained about the more intelligent classes in districts in which there are large numbers of illiterates is less accurate as a rule than information obtained about the same class of persons in districts where the general average of education is higher. The evident explanation is that the census enumerators held more consistently to high standards of accuracy in those regions where a high average of accuracy was possible.

The number of centenarians in the population is grossly exaggerated in the returns, this exaggeration being especially marked in the case of the more illiterate classes.

The median age of the aggregate population of continental United States (that is, the age which exactly divides the population into halves) is 22.85 years. One-half of the population is above that age, one-half below it.

One hundred years ago the median age was 15.97; since 1820 it has increased, on the average, by two-thirds of a year each decade. The median age of the population living in cities of over 25,000 inhabitants is about three and one-half years greater than that of the population living in smaller cities and rural districts.

This difference may be attributed to two main causes—the higher birth rate of the rural districts, and the migration from the country to the cities, which, like migration from abroad, consists largely of adults. Moreover, the cities contain a larger proportion of foreign born persons than do the rural districts. The median age is high in the North Atlantic and Western States and low in the South Atlantic and South Central States. In the North Central division it approximates that of the country as a whole. The average age (that is, the quotient resulting from dividing the total years lived by the living population) is some years higher than the median age, being, for the aggregate population in 1900, 26.2 years.

About three-fifths of the total population of the United States are between fifteen and sixty years old—comprising what is sometimes called the "productive" age group. This is a larger proportion of the population than is found in the same age group in most European countries—a fact which is due to the large number of foreign born adults in our population. But the only European countries which have so small a proportion of their population at "productive ages" as is found in the native white population of the United States are Holland and the Scandinavian countries.

Nearly one-fourth of the population are less than ten years old and over three-sevenths are less than twenty. Less than one-seventh have accomplished half the possible hundred years of human life, and only twenty-three out of every thousand have passed the allotted "threescore years and ten."

The greater average maturity of the urban population, shown by a higher median age, is due to the relatively larger proportion in the period of early middle

life. The rural population is relatively more numerous at both extremes of the age table.

Children reported as less than a year old constitute 2.5 per cent of the aggregate population, while children under five constitute 12.1 per cent. Both of these proportions are considerably smaller than they were in 1880, and are smaller than the corresponding ratios for most European countries. The proportion of children under 1 in the total population varies from one in thirty in Utah to one in sixty in California. The number of children in the population is relatively least in New England and on the Pacific coast; it is relatively highest in the South and in some of the newer agricultural States of the West and Northwest.

Of the aggregate population 51 per cent are males and 49 per cent are females, but in the age groups of fifteen to nineteen years, twenty to twenty-four years, and eighty years and over there are more women than men. These facts are shown to be in general agreement with the statistics respecting the relative numbers of the sexes born and the death rate of the sexes at various ages. The difference between cities and rural districts, with respect to the proportions of the sexes in the different age groups, are such that they can be only partially explained by the differences between rural and urban death rates; they consequently lead to the conclusion that females predominate among the younger persons migrating from the country to the cities, while males predominate among the migrants who are of middle age.

A FORTY-INCH SLABBING MILL.*

A new 40-inch universal slabbing mill, built by the Mesta Machine Company, Pittsburg, Pa., has recently been installed in the National Tube Company's plant at McKeesport, Pa. On account of the remarkable size of this mill and some novel features introduced in its construction, it stands out as a good example of modern construction and manufacture in rolling mill machinery. The mill is of the two-high reversible type, having two horizontal steel rolls 32 inches in diameter and 65 inches long, and is designed to take ingots 56 inches wide and 36 inches thick and to reduce them to any thickness within reasonable limits, and to a width down to 14 inches. The entire mill, including the reversing engines and roll tables, as shown in Fig. 1, was made by the Mesta Machine Company, and is therefore characterized by uniformity and harmony in design.

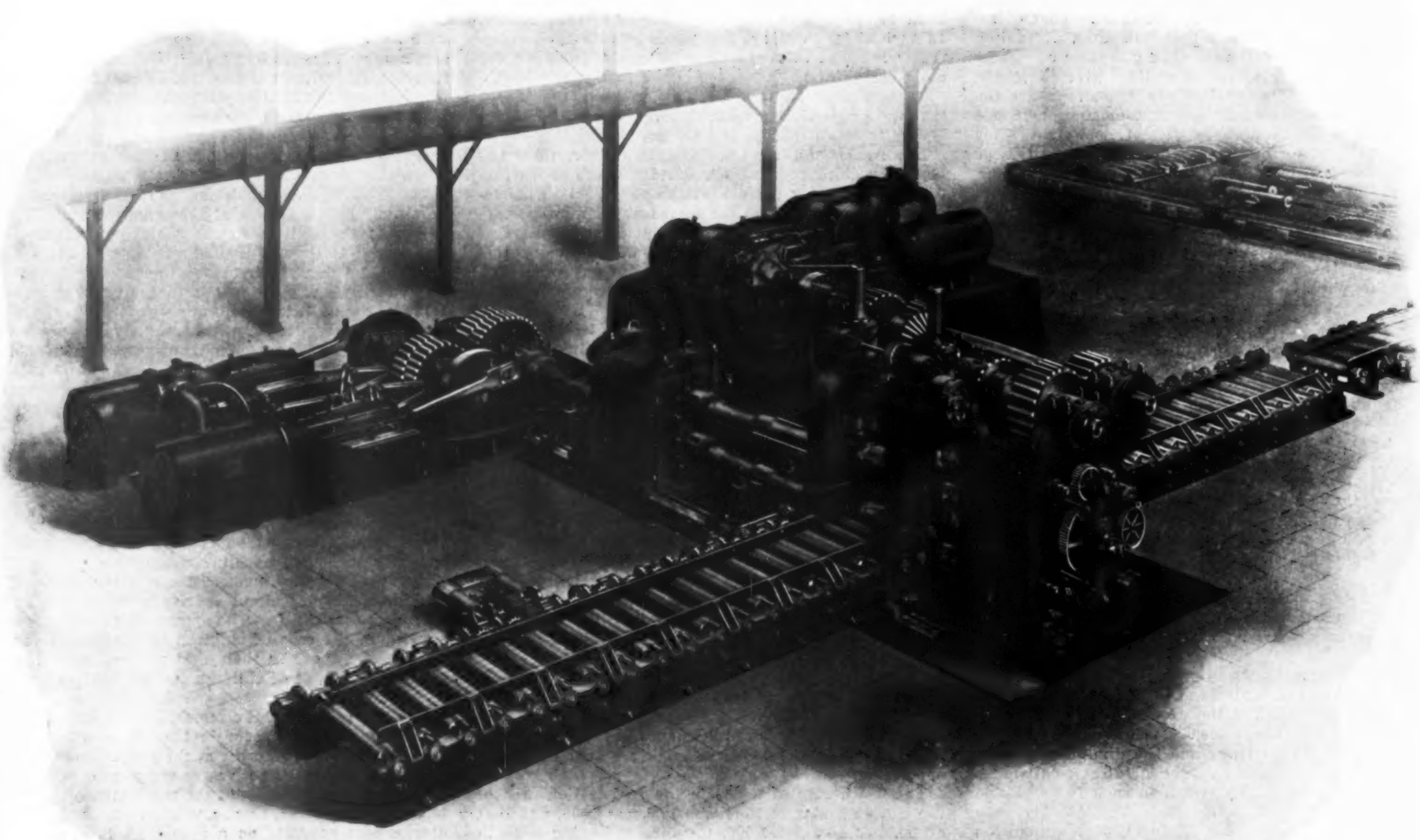


FIG. 1.—THE 40-INCH SLABBING MILL COMPLETE, WITH TWO 40 X 60-INCH ENGINES DRIVING THE HORIZONTAL ROLLS AND TWO 36 X 48-INCH ENGINES DRIVING THE VERTICAL ROLLS.

The horizontal rolls are mounted on housings of the usual type made of air furnace iron, each weighing about 50 tons. A pair of 46-inch x 60-inch Mesta piston valve geared reversing engines drive the horizontal rolls. The gears are machine-molded and are of the step-tooth design. The pinion is made of cast steel throughout. The rim of the gear is made of cast steel, and is mounted on a cast-iron center.

For driving the vertical rolls in a mill of this type, it is desirable to use as large miter gears as possible. In some mills where the miter gears are mounted in the same plane, it has been necessary to introduce one and sometimes two idler rolls, so that narrow slabs may be rolled. A distinctive feature of the mill under discussion is the ingenious arrangement of the vertical rolls, whereby only two of these rolls are used. These can be brought to within 14 inches of each other for rolling narrow slabs, although large miter gears are used for driving the rolls, a result accomplished by placing one miter gear above the other, so that in bringing the rolls close together one overlaps the other. Where one or two idler rolls are employed, they are, in some cases, driven by spur gears, but as these cannot be larger than the diameter of the rolls, they wear out very rapidly. Where the idler

* Specially prepared for the Scientific American Supplement.

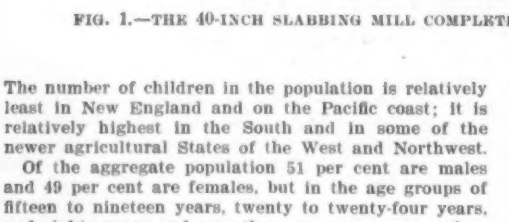


FIG. 2.—VERTICAL SECTION THROUGH THE CENTER OF THE MILL IN A PLANE AT RIGHT ANGLES TO THE HORIZONTAL ROLLS.

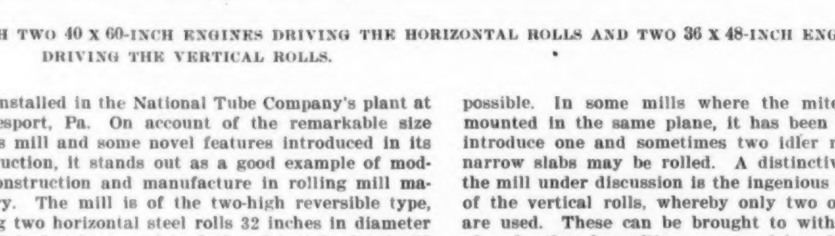


FIG. 3.—VERTICAL SECTION THROUGH THE MILL PARALLEL WITH THE HORIZONTAL ROLLS.

A 40-INCH SLABBING MILL.

rolls are not gear-driven they often slip in passing the ingot through, so that it is impossible to make a large reduction on the ingot at a single passing. In the mill illustrated, by making the rolls with a rough surface and driving them through the large miter gears, a large reduction on the ingot can be made at a single passing. With this mill a number of widths of slabs can be rolled from the same size ingot, whereas with the mills capable of only a small reduction, a special size of ingot is required for almost every width of slab.

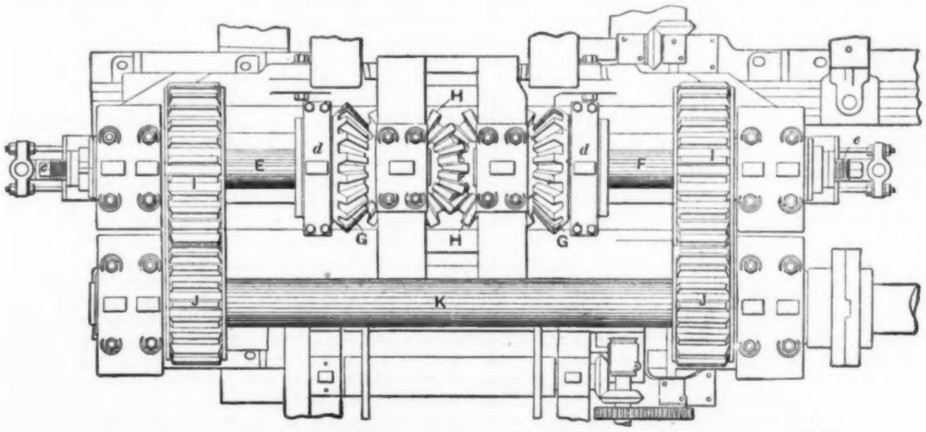


FIG. 4.—PLAN VIEW OF THE MILL, SHOWING GEARING FOR THE VERTICAL ROLLS.

The vertical rolls are mounted in bearings, supported on rest bars secured to two large housings, made of air furnace iron and weighing 70 tons each. The power for driving the rolls is furnished by a pair of 36-inch x 48-inch piston valve reversing engines, designed by the builders of the mill, mounted on a raised foundation. This engine is direct-connected with a shaft upon which are mounted two machine-molded cast-steel spur pinions. These pinions engage two machine-molded cast-steel spur gears which are carried on two shafts, upon each of which is also mounted a machine-molded cast-steel miter gear, which engages in its turn the miter gear on each one of the rolls, and transmits the power to same.

The construction of the mill is shown in Figs. 2, 3, and 4. In Fig. 2, which represents a vertical section through the center of the mill at right angles to the horizontal rolls. *A* and *A* represent the horizontal rolls, and *B* their housing. *C* is one of the vertical rolls, upon the upper projecting end of the trunnion of which the miter gear *H* is mounted. The gear *H* intermeshes with miter gear *G*, which is mounted on a shaft *F*, upon which the spur gear *I* is also carried. This spur gear intermeshes with the spur pinion *J* mounted on shaft *K*, with which the engine is direct-connected by a coupling.

The offset of miter gears *H* and *H* is clearly shown in Fig. 3, which represents a vertical section through the mill, parallel with the horizontal rolls. Upon the shafts *E* and *F* are mounted the miter gears *G* and *G* intermeshing with the miter gears *H* and *H* on the vertical rolls *C* and *C*, and also the spur gears *I* and *I* which receive motion from the spur pinions mounted on the shaft *K* connected with engine.

The plan view of the mill, Fig. 4, shows the gearing for the vertical rolls very plainly. The lettering of the different parts corresponds with lettering on Figs. 2 and 3. Shaft *K*, connected with the engine, extends across the mill, with the spur pinions *J* and *J* intermeshing with the spur gears *T* and *T* on the shafts *E* and *F*.

The opening between the vertical rolls is adjusted by moving sideways the travelers *D* and *D*, Fig. 3, to which are attached the bearings in which the rolls are carried. These travelers move in guideways cut in the transverse rest bars extending between the end housing. The upper rest bars are supported upon inwardly-projecting ledges cast on the end housings, while bearings for the lower bars are provided on the foot of the housings. Upper bolts *i* and *i* and lower bolts *j* and *j* extend through spacing blocks and serve to strengthen the rest bars. The adjustment of the travelers is done by screws *e, e, e, e*, which extend through the housing. The intermediate gears *g* and *g* transmit the motion to spur gears *f, f, f, f*, which revolve these screws.

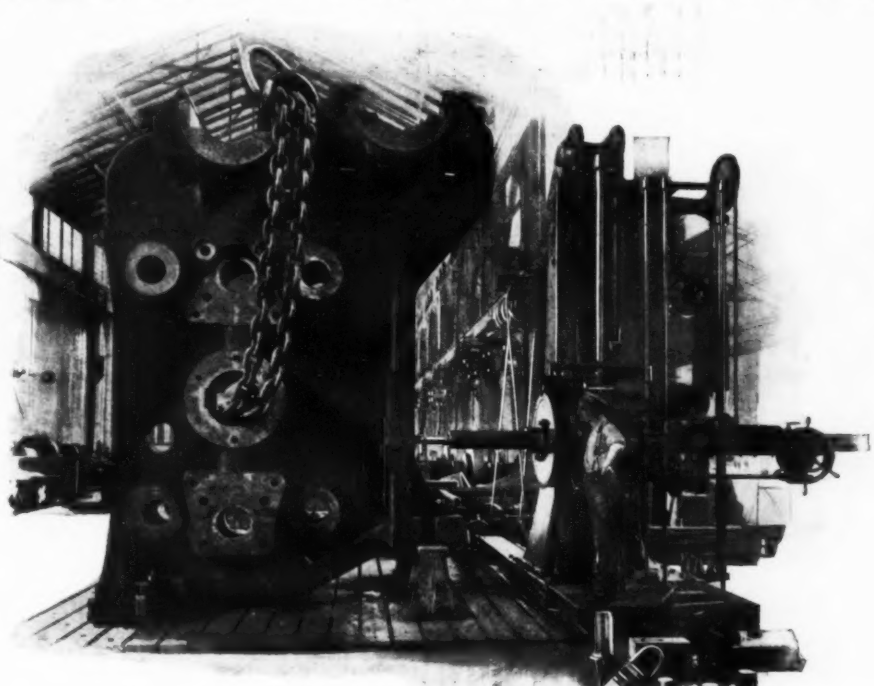


FIG. 5.—ONE OF THE 70-TON HOUSINGS FOR THE VERTICAL ROLLS.

A single-acting hydraulic cylinder with a plunger *H* is provided for each housing. Side rods secured to crossheads on the plungers, and bolted to the travelers, hold these securely against their adjusting screws.

The lower ends of the vertical rolls rest upon thrust plates *b* and *b* in step bearings. These bearings are provided with a semispherical extension, which rests in corresponding grooves on levers supported on the travelers. A self-adjusting step bearing is thereby provided. The levers are adjusted by means of adjusting screws *c* and *c* entering into the travelers and provided with adjusting nuts.

All the housings are made of open-hearth furnace iron in the foundries of the builders, and all the gears are molded on Mesta molding machines and made from cast steel.

Electric Equilibrium of the Sun.—Svante Arrhenius frames a theory of the process by virtue of which the sun is able to give out a continuous supply of negative electricity without its positive electrification being raised to such a high point as to retain the negative electrons in the sun. This process necessitates some form of circulation or renewal of the negative electricity in the sun, and the author makes such a circulation very plausible. We know that negative ions condense vapors more easily than positive ions. The gases in the atmosphere of the sun are ionized by the ultra-violet radiation. Therefore, we have to suppose that among the little drops formed by condensation in the sun's atmosphere far more are negatively charged than are positively charged. As these drops are driven away by the pressure of radiation they charge with negative electricity the atmosphere of celestial bodies, such as the earth, till the charge is

FIG. 6.—SIDE VIEW OF THE MILL, PARTLY ERECTED.

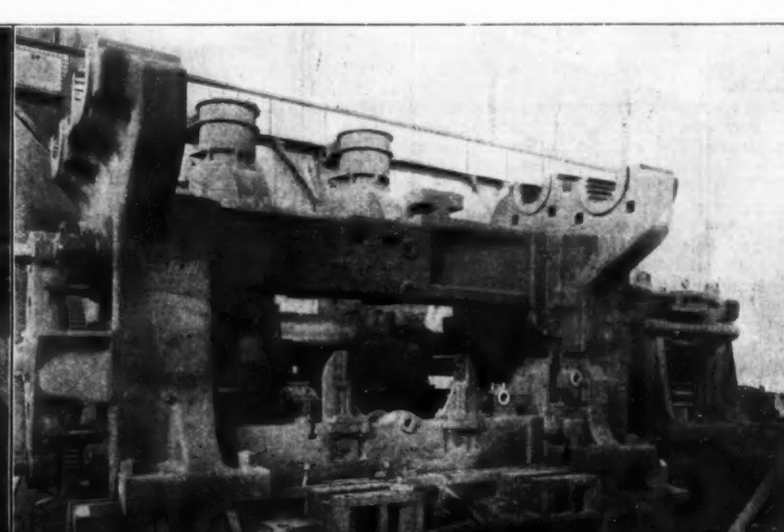


FIG. 7.—THE MILL PARTLY ASSEMBLED, SHOWING THE TWO 70-TON HOUSINGS WITH TRANSVERSE REST-BARS FOR THE VERTICAL ROLLS.

A 40-INCH SLABBING MILL.

so great that discharges occur, and cathode rays are formed, which carry the charge back to the universe. The author makes an interesting calculation of the speed with which the drops will be driven from the sun, assuming that the radiation pressure is twice their weight. A drop which partly reflects the light will arrive at the earth in about forty-six hours. Now, according to Ellis, the interval elapsing between the passage of a sun spot across the meridian and the maximum of the consequent magnetic storm upon the earth is 42.5 hours. This agreement renders the base of the calculation reasonably probable. The author then goes on to show that the charge of the sun is sufficient to attract and absorb negative electrons traveling with observed velocities anywhere within 1.25 light years of the sun. Since the nearest star is four light years away, and there are other stars about ten light years off, not many electrons can traverse interstellar space without being attracted by some star or other. Thus the suns recover from space as much negative electricity as they lose. The electric charges of the suns are very effective regulators. If the charge is quadrupled the mean distance of the caught electrons is doubled, or, in other words, as they are uniformly disseminated in space, their quantity is quadrupled. Therefore, the supply of negative electricity to the suns is proportional to their defect thereof.—S. Arrhenius, Proceedings of the Royal Society, June 2, 1904.

A NEW WORK ON METAMORPHISM.*

This treatise is an attempt to reduce the phenomena of metamorphism to order under the principles of physics and chemistry, or more simply, under the laws of energy. Metamorphism is broadly defined to include all alterations of all rocks by all processes. The metamorphism of the sedimentary rocks was the first subject studied by the author, and metamorphism has been a chief line of investigation with him for more than twenty years. Finding that the alteration of rocks was nowhere systematically treated, he took up the task of preparing such a work. It was supposed that this work would occupy two or three years, but as a matter of fact it required seven years, and an eighth year has been needed to put the volume through the press.

The book consists of twelve chapters. Chapter I. discusses the geological principles upon which a classification of metamorphism may be based. From this discussion it is concluded that the only practicable classification of metamorphism is geological. It is found that the alterations of the outer zone of the earth are radically different from those of the deep-seated zone. Moreover, it is shown that the alterations in the upper zone result in the production of simpler compounds from more complex ones, while those in the deep-seated zone result in the production of complex compounds from more simple ones. The upper zone is called that of katamorphism, and the lower zone that of anomorphism.

Chapter II., upon the forces of metamorphism, discusses chemical energy, gravity, heat, and light. The manner in which each of the classes of energy produces various mechanical and chemical effects upon rocks is set forth.

Chapter III. treats of the agents of metamorphism. The agents of metamorphism are gaseous solutions, aqueous solutions, and organisms. Under aqueous solutions the chemical and physical principles controlling the action of ground water and the circulation of ground water are fully discussed. This involves a full *résumé* of the science of physical chemistry so far as applicable to the alteration of rocks. This *résumé* is not simply a summary from text books of physical chemistry, but discusses the applications of the principles to the phenomena of metamorphism.

Chapter IV., upon the zones and belts of metamorphism, discusses these zones and belts from the physical-chemical point of view. It is shown that the alterations of the zone of katamorphism occur with liberation of heat and expansion of volume, the chief reactions being oxidation, carbonation, and hydration. The alterations of the zone of anamorphism occur with absorption of heat and diminution of volume, the chief reactions being deoxidation, silication with decarbonation, and dehydration. Thus the alterations in the two oppose each other. The zone of katamorphism is divided into two belts, that above the level of ground water, the belt of weathering, and that below the level of ground water, called the belt of cementation. While the physical-chemical principles of alteration are the same in each of these belts, the geological processes are very different. The belt of weathering is characterized by solution, decrease of volume, and softening, resulting in physical degeneration. The belt of cementation is characterized by deposition, increase of volume, and induration, resulting in physical coherence.

Chapter V. treats of minerals. Each of the rock-making minerals is discussed with reference to its occurrence and alterations. The alterations are considered from the physical-chemical point of view. An attempt is made to write chemical equations which represent the transformations, and to calculate the volume relations resulting. It is found that a great number of rock-making minerals undergo two classes of changes, one of which is characteristic of the zone of katamorphism, and the other of which is characteristic of the zone of anamorphism. Perhaps the most important generalization of this chapter is as to the reversibility of reactions in the two opposing zones. This generalization is as follows: The equations which represent the reactions in the zone of katamorphism are reversible in the zone of anamorphism; and so far as there is expansion of volume and liberation of heat in the upper zone, just so far is there condensation of volume and absorption of heat in the lower zone.

Chapter VI. considers the belt of weathering. The belt of weathering being the one which is most readily observed, has been treated by many authors. The chapter in this volume on weathering differs from previous discussions in that the phenomena are not considered mainly from the descriptive point of view, the emphasis being given to the classification of the phenomena and their explanation under physical and chemical principles. Also an important feature of this chapter is the consideration of the phenomena of the belt of weathering in relation to the alterations of the other belts of metamorphism.

Chapter VII. treats of the belt of cementation. This belt is defined as extending from the belt of weathering to the bottom of the zone of fracture. The geological results are found to contrast very markedly from those of the belt of weathering. In the latter belt solution is the rule; openings are enlarged; the rocks degenerate. In the belt of cementation, upon the other hand, the processes of metamorphism continuously deposit material, the openings are closed, and thus the rocks are consolidated. Each of the cementing substances is considered, and an explanation is offered as to why cementation rather than solution is a general process in this belt.

Chapter VIII. treats of the zone of anamorphism. This is the zone in which rock flow occurs. Full explanations of the meaning of rock flow and of the development of such secondary structures as slatiness, schistosity, and gneissosity are offered. Perhaps the most important generalization is that "rock flow is mainly accomplished through continuous solution and deposition, that is, by recrystallization of the rocks through the agency of the contained water. But rock flow is partly accomplished by direct mechanical strains. At the beginning of the process, during the process, and at the end of the process, the rocks, with the exception of an inappreciable amount, are crystallized solids."

Chapter IX. treats of rocks. A classification of the sedimentary rocks is given, their genesis is discussed, and the series of transformations through which each of the rocks passes is traced out, the resultant rocks being indicated. It was not found possible to give a similar treatment for the igneous rocks.

With the ninth chapter, the subject of metamorphism proper closes, but the results contained in these nine chapters have an important bearing upon other parts of physical geology. The remaining chapters consider these relations.

Chapter X. discusses the relations of metamorphism to stratigraphy. It is shown that in consequence of metamorphism great difficulties are introduced in stratigraphical work. The nature of the difficulties and the manner in which they may be overcome are fully considered.

Chapter XI. treats of the relations of metamorphism to the distribution of the chemical elements. This is perhaps the most daring of the various attempts at generalizing of the treatise. It is shown that as a result of the forces and agents of metamorphism the elements of the original igneous rocks are redistributed, a given element being less abundant in the larger number of sedimentary rocks than in the original rocks, and corresponding with this depletion each of the elements is segregated in one or more formations. An attempt is made to treat the problem of the redistribution of the elements quantitatively. Assumptions are made as to the total mass of the sediments and of the relative proportions of the more important classes of sediments. Combining these assumptions with the results of chemical analyses, the losses and gains of various formations for each of the important elements of the earth are considered. Many surprising results are reached. For instance, we find the conclusion that to oxidize the ferrous iron of the original rocks to the ferric condition in which most of it occurs in the sedimentary rocks, 35 per cent of the amount of oxygen in the atmosphere has been required. But still more startling is the conclusion that to oxidize the sulphur and iron of iron sulphides in order to produce the sulphates of the ocean and gypsum deposits, and to transform the iron to the ferric form required one and one-half times the amount now in the atmosphere.

The final chapter of the book, XII., is upon the relations of metamorphism to ore deposits. It is probable that this chapter will receive more general attention than any other. The material of the other chapters is of a kind which is likely to be of interest to the geologist only, whereas this chapter is of interest to all men concerned in the great mining industry. The chapter upon ore deposits occupies 240 pages and, indeed, might have been named "The principles of ore deposition." From the author's point of view, the majority of ore deposits are produced by metamorphic processes. Having worked out the general principles of metamorphism with reference to rocks, the author found that the application of these principles to ore deposition explained the majority of ore deposits. From his point of view the proper theory of ore deposition consists mainly in bringing the particular phenomena exhibited by ore deposits under the general principles of metamorphism. The chapter contains a new classification of ore deposits, the fundamental divisions of which are the same as those of rocks. Thus ore deposits are divided into three classes, those of sedimentary origin, those of igneous origin, and those of metamorphic origin. Strictly the treatise on metamorphism should, perhaps, have considered only the third class. However, the first and second classes are sufficiently discussed so that the relations of these ores to those produced by metamorphic processes may be appreciated. The discussion upon ore deposits is too elaborate to be summarized in this general statement. But it may be remarked that for the metamorphic ores an attempt is made to trace out the solution, transportation, and precipitation of each of the chief economic metals. Also the alterations and further segregation of metals are fully considered. The conclusion is reached that in many cases an ore deposit does not represent a single segregation, but is the result of repeated segregations by the same general processes which result in the depletion in certain elements of the various rock formations and their segregation elsewhere. In other words, the principles of the development of ore deposits are the principles of the segregation of those elments which are of importance to man, but which, for the most part, are so rare that they are not included in the discussion in the chapter upon the redistribution of chemical elements.

It is not possible in a summary to give any adequate idea of the scope of this treatise on metamorphism. A very broad range of facts, extending far beyond what might at first be regarded as a part of a treatise on metamorphism, is considered from the energy point of view. It is believed that the volume marks a great stride in the reduction of the entire subject of physical geology to order under the principles of physics and chemistry, and points out the way for a treatment of the entire subject from this point of view.

* A Treatise on Metamorphism. Monograph XLVII. By Charles Richard Van Hise. Washington, D. C.; The United States Geological Survey.

DESTRUCTION OF RATS AND MICE.

In certain departments of France rats and mice have committed such depredations on vines and growing crops that the losses arising therefrom have amounted to little less than a plague.

The Pasteur Institute claims to have discovered a means of destroying these rodents with complete success and in such a way that the means of destruction is absolutely harmless to domestic animals.

There appears to be no doubt that the claims of the Pasteur Institute can be established by facts, as far as the destruction of rats and mice is concerned; it does not yet appear to be proved clearly and unmistakably that the means employed for destroying the noxious animals mentioned is not hurtful to other forms of animal life to be found in agricultural and vine districts.

However, the results so far obtained have been so satisfactory to the French government that the Minister of Agriculture (M. Mougeot) has bestowed upon the manager of the Pasteur Institute the high and much-prized decoration of "Commandeur du Merit Agricole," while the "Rosette d'Officier" has been bestowed upon the manager's assistant.

On the 28th of last January Drs. Roux and Chamberland, in company with a general inspector of agriculture (M. de Lapparent), proceeded to the departments of the Charente, which district has suffered the most severely.

The preparation of microbes by the Pasteur Institute in a sort of soup (bouillon) is so well known in the United States in connection with the cure of rabies, diphtheria, etc., that no further allusion will be made here in the preliminary work of the laboratory. Dr. Roux brought with him to the scene of operations a large quantity of this "bouillon" swarming with the rat microbes.

The ground selected by Dr. Roux for his battle with the rats covered a space of 2,965 acres and extended over the communes of Aigre, Oradour, and Mons. Here various kinds of cereals, vines, and trees abound; and here also the sowing of various kinds of grain last autumn had been completely destroyed by these rodents. This meant also the destruction of fodder for cattle—such as lucern—hence butter and milk production was seriously affected. The ground throughout the district was literally perforated with holes, which seemed to be connected underground by little passages. Such was the condition of the scene of operation of Dr. Roux, which certainly seemed to offer a severe test for the efficacy of his discovery.

Dr. Roux succeeded in interesting the farmers of the district in these very important experiments and very soon the celebrated scientist had organized a corps of assistants on the spot. These assistants, under the direction of Dr. Roux, dipped quantities of wheat, oats, and small pieces of bread, about 0.3937 inch square, into the bouillon referred to and which consequently became immediately impregnated with the microbes which the bouillon, or soup, contained.

Then the poisoned wheat, etc., was placed in and about the holes where the rats and mice were known to be. The total quantity of poisoned "paste" distributed amounted in all to 4.2 metric tons of bread and 9.3 metric tons of oats, while the quantity of bouillon, or soup, used was 1,190 bottles. The total area of these experiments, as above indicated, was 2,965 acres.

The time employed by the farmers who, under Dr. Roux's instructions, distributed this paste represented about one thousand two hundred half days—from 1 to 5 o'clock in the afternoon.

To determine the effect of this poisoned paste on these destructive little animals Dr. Roux had the fields that had been microbe-treated plowed up in order to see the condition of the rodents after they had eaten the paste and to fix approximately the number of rats and mice that had succumbed to the poison. The results obtained surpassed all expectations on the part of the simple farmer. Rats and mice were dead in almost alarming quantities and became quite as much of a pest when dead and putrefying as when they had been alive, but happily in another sense of the word. Dr. Roux estimates that he destroyed no less than 95 per cent of the rodents by these experiments. As many as 15 to 20 rats were sometimes found in one hole.

Not satisfied with this ocular demonstration of the success of his paste, Dr. Roux proceeded to a field of an area of about 2½ acres and surrounded by vines. Here he had a number of rat holes counted, this number being fixed at 12,484, which were carefully closed. Two days later the holes were again visited and it was found that 1,304 had been reopened by the rats. The poisoned paste was again brought into requisition. Eight days afterward the field was visited and the holes which had been opened counted, the process being again repeated two days later; the holes that had been opened by the rats were found to be 37.

The Minister of Agriculture, on being satisfied with the results thus obtained by Dr. Roux, and acting on the advice of the eminent scientist, proposes to introduce into the Chamber of Deputies a bill for the purpose of compelling farmers in rat-infested districts to co-operate in using the above-described paste. In this way it is hoped that a field, for instance, which has been rid of rats will not be visited by rats from surrounding fields which have not been treated with the poison. The cost of this paste, including its application, is estimated at about 5 francs (96 cents) per hectare (2.471 acres).—John K. Gowdy, Consul-General at Paris.

TRADE NOTES AND RECIPES.

Leather Varnish.—An excellent varnish for leather can be made from the following recipe: Heat 400 pounds of boiled oil to 100 deg. C., and add little by little 2 pounds of bichromate of potash, keeping the same temperature. The addition of the bichromate should take about fifteen minutes. Then raise to 160 deg. C., and add gradually during one hour at that temperature, 40 pounds Prussian blue. Then heat for three hours more, gradually raising to 250 to 300 deg. C., with constant stirring. In the meantime, heat together at 350 deg. C., for half an hour, 25 pounds linseed oil, 35 pounds copal, 75 pounds turpentine, and 7 pounds ceresine. Then mix the two varnishes, and dilute if necessary when cold with turpentine. The varnish should require to be warmed for easy application with the brush.—Les Corps Gras.

How Best to Handle the Gilded Parts of a Watch.—The question before us is: Does it add anything to the beauty of the gilding, if the gilded parts of a watch are gone over with the buffing stick after removing them from the benzine. The Swiss Uhrmacher Zeitung finds such treatment unnecessary if, as must be presupposed, the benzine be clean and the wiping cloth also. Moreover, it is altogether faulty to make use of rouge—in this particular of course only gold red can be meant—because it leaves traces behind it easily discernible on the gilding, and which detract from the seemly appearance of the pieces; besides, some of the dried particles of the red stuff, remaining behind, get into the movement, and by constant friction injure it materially. Nor is it less detrimental to go over the gilded parts with the buffing stick, particularly when these have been washed for the last time before putting together—a process whereby the gilding is made more prominent. Under such treatment the effect of the benzine is for the greater part lost, when the parts that have been carefully dried are again subjected to a scouring with the brush and chalk. As for the smaller steel parts, and especially the winding wheels, these latter being often very much clogged with old oil, if these be put in the benzine it will become so soiled as to be scarcely available for use. It is rather more profitable to brush them out first and put them, except the lever, in a small bottle with a wide neck, and cover with sulphuric ether. They may now be shaken up, which assists greatly in the cleaning process, and afterward dried on a cloth.

Reclaiming Silver.—From large photographic studios there are often a quantity of things to be obtained which, if properly and cleverly treated, will yield silver very cheaply to the worker in that metal.

In a popular studio, during a year or even a month, there is much waste, such as plates, films, unsuccessful exposures, uncalled-for photographs, and the like, not to mention the developing and fixing solutions, that contain silver in one form or another.

Little is thought of this, and we believe it is now time to call the silversmith's attention to the fact that there is a small mine in these waste materials. Not infrequently the photographer is pleased to be rid of the incumbrances for the removal of them. On the other hand, it will often pay to make a satisfactory offer for them, and clean up once a month.

With a view to reclaiming the silver, place any or all of the above-named articles in a porcelain dish so arranged that they will burn readily; to facilitate combustion, a little kerosene or denaturized alcohol poured over the contents will be found serviceable.

Before blowing off the burnt paper, place the residue in an agate-ware dish, the bottom of which is covered with a solution of saltpeter and water. Place the whole on the fire, and heat it until the silver is separated as a nitrate.

The solution being complete, add to the mass a little water and hydrochloric acid, when in a short time the serviceable silver chloride will be obtained. If the films should not give up their silver as freely as the plates, then add a little more hydrochloric acid or work them up separately the next time. Silver reclaimed in this way is eminently suitable for silver-plating all sorts of objects.

To test old silver coins and other articles of old silver, that one buys to melt down, as to their value and purity proceed as follows:

Lay them for fifteen minutes in a solution of common salt (about 30 grammes of salt to a liter of water). If the articles are of real silver they will not change, but if they are for the most part of nickel, they will take on a violet hue, which increases in intensity the longer they remain in the solution. If tin be a part of the alloy, the articles will become of a dead gray. If the old objects are dirty, it will be well to wash them in ammonia-soap water.

If there be so much verdigris on their surface that their true value cannot be estimated, lay them in a solution of 1½ parts of acid and 50 parts of water for ten minutes. The verdigris dissolves rapidly away, and the cleansed silver may then be melted up for use in silver jewelry.—Journal der Goldschmiede Kunst.

ENGINEERING NOTES.

In a paper recently published in the Revue Technique, M. L. Levi makes the following comparison between the calorific values of different fuels used in internal-combustion engines; British thermal units per pound—methylated alcohol, 10,620; methylated alcohol mixed with 50 per cent gasoline, 14,200; crude American oil, 19,630; refined American oil, 19,880. The mixture of methylated alcohol can, it is stated, be used as easily as ordinary gasoline, but with unmixed gasoline it is necessary to warm up the carbureter a little before starting, as the alcohol does not vaporize readily enough below a temperature of 68 deg. F. As an alternative gasoline may be used at the start, the alcohol being supplied later. No trouble is found with the admission valves in using alcohol, and if at times there is a deposit of soot or tar, this arises generally from the use of a bad carbureter. A little acetic acid results on combustion, but not enough to cause damage. The carbureter should be of a type which will deal out a measured quantity of the liquid at each suction stroke. The exhaust gases are free from the unpleasant smell prevalent in the case of gasoline motors. The principal objection to the use of spirit lies in cost, which, to compete with gasoline, should be about 20 cents per gallon in place of about twice as much, as at present the case in France. In Germany the cost of methylated alcohol is only about 18 cents per gallon, so that the alcohol motor is becoming more and more popular there.

Two ingenious devices for use in the cotton-spinning industry have been recently patented in England. The first comprises an automatic weaving attachment. As in the Northrop, the cop is changed, but not the shuttle. The device differs from the latter, however, inasmuch as it is used with overpick looms. In operation the breaking of the weft throws the weft fork out of action, and a new cop falls down, forces the old cop into a receptacle below, at the same time taking its place. The device has been submitted to several severe tests, one of which was a continuous four hours' run, and has proved highly successful. It can be fitted easily and cheaply to existing looms, and is applicable to both plain and fancy weaving. The second invention has been introduced by Mr. Paley, a cotton manufacturer of Preston, Lancashire. This is a new type of brake ring, the scope of which is to improve the efficiency of the ring frame. One of the drawbacks to the existing ring frame is that it can only be used for warp yarns, up to about 80's, and up to 100's in cases of extreme necessity, while for hard weft yarns its capacity is up to 50's. For some time past a means of obtaining a positive variation in the traveler, according to the diameters of the cop, has been desired. The advantages accruing from the use of the ring frame have been to a very appreciable extent nullified by the difficulty in spinning the higher numbers and soft wefts. The greater objection to the use of thick wooden pirns is that they do not hold a sufficient quantity of yarn, and are unduly weighty in proportion to the weight of the yarn. In the Paley device these difficulties are successfully surmounted. The invention consists of an external ring outside of the ordinary ring. A number of inclines resting on pins fixed on the ordinary ring are cut on the inside of the external ring. The latter is moved round the stationary ring by a projecting wire, which is provided with a longitudinal rod in front of the ring rails, and which is moved endwise so as to obtain the requisite revolution of the brake ring. When the frame commences to spin, a traveler of sufficient weight is used to enable spinning to take place at the nose of the cop with the minimum of turns per inch, such as is usual to put into mule yarn. As the ring rails fall toward the shoulder of the cop, the rod slides along to the rails to the right, and turns the external ring round the fixed inner ring. This operation causes the outer ring to rise up the inclines on its under edge and come in contact with the traveler, thereby braking or retarding it. This effect, however, is so gentle and regular in its action, that the traveler is virtually converted into one of varying weights, this variation coinciding with the varying angle of pull on the yarn. With this device the yarn is softer, fuller, and of greater strength than that spun under ordinary circumstances, and is as full and "oozy" as mule yarn, with greater elasticity. Furthermore, what is of equal importance is that the increase in production is as much as 100 per cent, and yarns varying from 10's to 150's are possible. The device is already in operation upon 12,000 spindles, and has proved eminently successful.

SCIENCE NOTES.

The Journal of the Society of Arts states that among the congresses arranged in connection with the Liège International Exhibition of next year, and with which the co-operation of the Belgian government is assured, one on chemistry and pharmacy, convoked by the Belgian Chemical Society and the Liège Pharmaceutical Association, will be held at the end of July. The congress is to be divided into the following sections: (1) General chemistry, physico-chemistry; (2) analytical chemistry, apparatus and instruments; (3) industrial mineral chemistry, including metallurgy; (4) industrial organic chemistry (sugar-boiling, fermentation, tanning, dyeing, etc.); (5) pharmaceutical chemistry; (6) the chemistry of food substances; (7) agricultural chemistry, manures; (8) biological and physiological chemistry (application to hygiene and bacteriology); (9) toxicology; (10) practical pharmacy; and (11) legislation and professional interests, deontology. The president of the organizing committee is Prof. A. Gilkinet, of Liège.

The directors of the Ben Nevis Observatories, which were closed on October 1, have just issued a circular describing the circumstances in which these observatories have at last been discontinued. The maintenance of the two stations at Fort William and on the summit of Ben Nevis has involved an average yearly expenditure of $5,000. Of this sum, $1,750 has been supplied by the Meteorological Council, and the remainder has been obtained from various private sources. It was hoped that the Treasury Committee which was appointed to consider the question of the annual grant to the Meteorological Council would deal adequately with the position of the Ben Nevis Observatories in its report, but in their circular the directors express disappointment that this was not done. The directors remark: "Some of their number, including the two secretaries, were examined, and fully stated their case, besides handing in detailed memoranda regarding the history, work, and cost of maintenance of the observatories. Yet, with all this information before them, the committee state in their report that 'it appears that only $1,750 per annum is required to insure the continued maintenance of the observatories.' The directors lost no time in calling the attention of the First Lord of the Treasury to this 'inexplicably erroneous' statement, and in appealing to him that means should be found to prevent the abandonment of the observatories. The treasury, however, could not see its way to any further increase of the contribution from the parliamentary grant, but offered to continue the allowance of $1,750 a year hitherto received from the Meteorological Council. As this arrangement would have left the directors exactly where they were before, face to face with the impossibility of continuing to raise $3,250 every year, and with the obvious hopelessness of obtaining adequate pecuniary support from the government, there was no alternative but to close the observatories."

A number of interesting communications relating to radio-activity were made at the Cambridge meeting of the British Association. Lord Kelvin, says Technics, stated that the earlier opinions regarding radium, to the effect that its emission of energy goes on for ever, had so alarmed him that he felt obliged to maintain that energy is derived from some external radiations absorbed by the radium. It has since been made plain that the radium atom has a life of limited duration (about 30,000 years) so that the above difficulty no longer exists, and therefore Lord Kelvin withdrew his opposition to the disintegration theory. Further, Lord Kelvin exhibited models illustrating the behavior of the radium atom. One of these consisted of two positively charged spheres (representing positively charged atoms) with a small negatively charged sphere (representing a negative electron) between them. The large spheres are held together by the interposed negative charge, but the state of equilibrium is unstable; a disturbance would cause one of the positively charged spheres to be projected away with considerable velocity. Lord Kelvin pointed out that if the structure of the radium atom were really like that represented by his model, the rate of disintegration would be greater at high than at low temperatures, which has been proved experimentally not to be the case; thus the models exhibited can only be considered to offer a partial and tentative explanation of the structure of radio-active atoms. Prof. J. J. Thomson made some interesting observations on radio-activity. He pointed out that McClellan and Strutt had simultaneously shown that the air contained by closed metal vessels has the capacity of discharging an electroscope; this is not a property merely of the air, since it depends on the metal composing the inclosing vessel, as well as on the volume of the vessel. With vessels of a liter volume the leak with lead is twice that with zinc. Further, if the vessel is placed with a lead cistern the ionization is decreased. In fact, if a sheet

of lead is held above the closed vessel, so as to shield it from the sky, the rate of ionization is diminished; if the sheet of lead is held below the vessel, so as to shield it from the earth, the ionization is also diminished. Mr. Cook, in Canada, surrounded his apparatus with a lead vessel weighing half a ton, and found that the decrease produced in the ionization was no greater than with an enveloping lead vessel two inches in thickness. A student at the Cavendish laboratory has sunk apparatus, similar to that described above, to a depth of sixty feet in a lake, and found that there is still a residual ionization. As a final result, it appears that every metal is to a certain extent radioactive, and emits two kinds of radiations, one of which is very penetrating, while the other is absorbed with comparative ease. The easily absorbed radiations from carbon have been found to be more penetrating than those from lead. There remains the possibility that all space is traversed by exceedingly penetrating radiations, which, falling on metals, cause the emission of radiations.

SELECTED FORMULÆ.

Lubricant for Ropes.—For hemp ropes, fuse together 20 pounds of tallow and 30 pounds of linseed oil. Then add 20 pounds of paraffin, 30 pounds of vaseline, and 60 pounds of rosin. Finally mix with 10 pounds of graphite, first rubbed up with 50 pounds of boiled oil. For wire ropes fuse 100 pounds of suint with 20 pounds of dark colophony. Then stir in 30 pounds of rosin oil and 10 pounds of dark petroleum.—Farben Zeitung.

Gold Varnish.—A varnish which will give a splendid luster, and any gold color from deep red to golden yellow, is prepared by taking 50 ounces pale shellac, 15 pounds Florentine lake (precipitated from cochineal or redwood decoction by alum on to starch, kaolin, or gypsum), 25 ounces of sandalwood, and 8 ounces of dragon's blood. These in fine powder are dissolved on the water bath in 500 ounces rectified spirit. The spirit must boil and remain, with occasional shaking, for two to three hours on the bath. Then cool and decant. In the meantime heat in another flask on the bath 30 ounces of gamboge in 500 ounces of the same spirit. The two liquids are mixed until the right color needed for the particular purpose in hand is obtained. Dilute with spirit if too thick. The addition of a little picric acid gives a greenish-yellow bronze, but makes the varnish very liable to explode. These varnishes are applied to gently warmed surfaces with a soft bristle-brush.—Hannoversches Gewerbeblatt.

Non-Poisonous Fly-Paper.—1. Mix 25 parts of quassia decoction (1:10) with 6 parts of brown sugar and 3 parts of ground pepper, and place on flat dishes. 2. Mix 1 part of ground pepper and 1 part of brown sugar with 16 parts milk or cream, and put the mixture on flat plates. 3. Boil down 75 parts of quassia wood with 200 parts of water to one-half, mix the colature with 5 parts of cobalt chloride, 1 part of tartar emetic, and 40 parts of tincture of long pepper (1:3 spiritus dilutus). Saturate blotting paper with this mixture, and lay on plates. 4. Macerate 20 parts of quassia wood with 100 parts of water for 24 hours, boil one-half hour, and squeeze off 24 hours. The liquid is mixed with 3 parts of molasses, and evaporated to 10 parts. Next add 1 part of alcohol. Soak blotting paper with this mixture, and put on plates. 5. Dissolve 5 parts of kali bicromic, 15 parts of sugar, and 1 part of essential pepper oil in 60 parts of water, and add 10 parts of alcohol. Saturate unsized paper with this solution, and dry well. 6. Boil 1 kilo of quassia wood chips with 4 liters of water, so that 2½ liters of colature result. To this add a tincture prepared from 300 grammes of long pepper extracted with 1,000 grammes of spirit (45 per cent). Finally add 200 of tartar emetic, agitate repeatedly, saturate paper, and dry on cords.—Pharmaceutische Zeitung.

Practical Receipts for the Making of Varnish.—

Coffin Varnish.—Take 60 kilogrammes of American resin and dissolve it together with 20 kilogrammes of Manila copal and 10 kilogrammes of gallipot in 80 kilogrammes of spirit.

Varnish for Labels or Tags.—Dissolve in 40 kilogrammes of spirit 6 kilogrammes of bright sandarac, 15 kilogrammes of light French resin, 9 kilogrammes of pale Manila copal, and add to it 6 kilogrammes of Venetian turpentine.

Varnish for Straw Hats.—Take 5 kilogrammes of pale sandarac, 15 kilogrammes of light rosin, 3 kilogrammes of thick turpentine, 10 kilogrammes of Manila copal, and 45 kilogrammes of spirit.

Glazing for Iron.—40 kilogrammes of yellow shellac and 60 kilogrammes spirit.

Glazing for Wood.—60 kilogrammes of cowrie mixing varnish and 40 kilogrammes of the glazing for iron are to be well mixed together.

Cowrie Mixing Varnish.—87 kilogrammes of cowrie gum dust dissolved in 109 kilogrammes of spirit.

Boot Polish or Leather Varnish. I.—Take 26 kilogrammes of light shellac, 6 kilogrammes of thick turpentine, 3 kilogrammes of castor oil, 3½ kilogrammes of aniline black, and 80 kilogrammes of spirit.

Leather Varnish. II.—With 15 kilogrammes Manila copal and 7½ kilogrammes ruby shellac take 3 kilogrammes Venice turpentine, 3 kilogrammes castor oil, 80 kilogrammes spirit, and 2½ kilogrammes aniline black.

Leather Varnish. III.—Dissolve 50 kilogrammes of Manila copal together with 25 kilogrammes of gallipot and 3 kilogrammes of aniline black in 80 kilogrammes of spirit.—Farben Zeitung.

THE

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